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QUARTERLY PROGRESS REPORT

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Date 11-3-94 Reviewer 137

DIVISION 6 — DIGITAL COMPUTER (U)

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15 DECEMBER 1957

[redacted]

LINCOLN LABORATORY

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HEADQUARTERS
NORTH AMERICAN AEROSPACE DEFENSE COMMAND
PETERSON AIR FORCE BASE, COLORADO 80914-5001

#1717

REPLY TO ATTN OF J30S

26 NOV 1984

SUBJECT Classification Review "Quarterly Progress Reports"

TO ALFL (Lincoln Laboratory)

1. In response to ALFL letter, 28 Nov 83, the (11) confidential documents titled "Quarterly Progress Reports - Division 6 - Digital Computer" and dated 15 Jun 1954 through 15 Dec 1958 have been reviewed. Recommend the documents be declassified in whole since the sage system computer no longer exists and information contained in the documents no longer has an effect on national security.

2. To officially declassify these, documents, the 416L Security Classification Guide OPR, which is at HQ Sacramento Air Logistics Center, McClellan AFB, CA (MMCM), must be contacted with the recommendation to declassify.

JOHN E. MOORS, LCOL, CF
Ch, At Sensors Division

Memo for Record 14 Dec 84

Talked, by phone, with Ed Smalden, Sacramento ALC/MMCM, McClellan AFB, CA. Based on the recommendation in this letter he considers these documents declassified.

THOMAS J. ALPERT, MAJOR, USAF
CHIEF, ESD LINCOLN LABORATORY PROJECT OFC

Atch 2

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS ELECTRONIC SYSTEMS DIVISION (AFSC)
HANSCOM AIR FORCE BASE, MASSACHUSETTS 01731

REPLY TO ATTN OF: ALFL (Lincoln Laboratory) 17 Dec 84

SUBJECT: Declassification of Lincoln Laboratory Documents

TO: Mr. M. Wesley/A-109
Security Office
Lincoln Laboratory

1. Reference your letter of 17 Nov 1983 requesting declaassification and public release of MIT Lincoln Laboratory Quarterly Progress Reports issued between June 1952 and December 1958 (see atch 1).

The first major hurdle of this process has been cleared. Attachment 2 authorizes the declassification of the following documents:

"Quarterly Progress Reports - Division 6 - Digital Computer"

15 Jun 1954 (C)-(LL # 1, C315172C)
15 Sep 1954 (C) (LL # 1, C315189C)
15 Sep 1956 (C) (LL # 1, C315208C)
15 Mar 1957 (C) (LL # 1, C315206C)
15 Jun 1957 (C) (LL # 1, C315253C)
15 Sep 1957 (C) (LL # 1, C315254C)
15 Dec 1957 (C) (LL # 1, C315255C)
15 Mar 1958 (C) (LL # 1, C315256C)
15 Jun 1958 (C) (LL # 1, C315257C)
15 Sep 1958 (C) (LL # 1, C315258C)
15 Dec 1958 (C) (LL # 1, C315313C)

The next major hurdle is obtaining public release. This will be done through ESD Public Affairs (Mr. John O'Brien).

ORIGINAL SIGNED BY

THOMAS J. ALPERT, Major, USAF
Chief, ESD Lincoln Laboratory Project Ofc

2 Atch
1. Lincoln Laboratory Ltr, 17 Nov 1983
2. NORAD Ltr, 26 Nov 84

Cy to: D. Murphy/B-107 w/atch
W. Hill/L-339 w/atch

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QUARTERLY PROGRESS REPORT

DIVISION 6 – DIGITAL COMPUTER (U)

15 DECEMBER 1957

ISSUED 1 AUGUST 1958

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY LEXINGTON, MASSACHUSETTS

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DIVISION 6 SUMMARY

In the Experimental SAGE Sector (ESS), Phase II of shakedown testing was conducted with Model O of the direction center active (DCA) program; gap filler radars were used for the first time and the Montauk long range radar site was integrated with the system. The responsibility for SAGE DCA program installation was turned over to the System Development Corporation with the McGuire program installed and tested and the Stewart and Syracuse programs still under test. At the Syracuse Combat Center, the combat center active (CCA) program had been parameter checked and assembly checking was well under way. Specifications for antiaircraft defense and improved manned interceptor capability for 1959-60 SAGE were in preparation. The assembly of the experimental computer, TX-2, continued: new circuits use graded-base transistors to reduce the number of components and shorten operating time.

Phase II of shakedown testing in the Experimental SAGE Sector (ESS) began on 1 October with the objectives of verifying the latest model of the air defense program, integrating additional radar sites, improving operator efficiency, and correcting system malfunctions. Thirty-three test periods, eighteen with live aircraft, were held using Model O, the first revised version of the complete direction center active (DCA) program. Gap fillers were used for the first time in system tests and the Montauk radar site was integrated with the system.

On 1 October the SAGE DCA program installation responsibility was turned over to System Development Corporation. At that point the complete initial version of the direction center active (DCA) program had been installed at McGuire, was 50% tested at Stewart, and had just been introduced at the Syracuse Direction Center. Ninety per cent of the combat center active (CCA) program for the AN/FSQ-8 at the Syracuse Combat Center had been parameter checked by the end of the quarter. The air surveillance portion of the program was about 95% assembly tested.

Seven System Office Recommendations were issued by Technical Information Release (TIR) which covered changes to be included in Model 1 (second revision) of the SAGE direction center active (DCA) program.

Participation in the planned integration of new weapons in 1959-60 SAGE continued with drafts of specifications for antiaircraft defense and improved manned interceptor capability now under study. The radar data generation and tracking portions of the SAGE non-real-time (SNORT) simulation were nearing completion, while the Canadian SAGE-BOMARC Analysis (CASBA) simulation was employed to study SAGE tracking effectiveness. Modifications were made to the ESS DCA program to improve its tracking ability and to prepare for shakedown of the crosstell function. Support for these and other programming efforts was strengthened by the consolidation of new and existing laboratory card- and tape-processing equipment.

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The assembly of the TX-2 experimental computer continued satisfactorily. New circuit designs which take advantage of graded-base transistors not available a year ago use fewer components and shorten operating time by several tenths of a microsecond. Twenty-one core memory planes for the transistor-driven core memory ($64 \times 38 \times 19$) have been accepted and three have been wired into the memory stack. Progress in the studies of magnetic materials is now being reported in Lincoln Laboratory Quarterly Progress Report, Solid State Research, Groups 24, 35, 37, 63, and 310 (Unclassified).

R.R. Everett
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24 June 1958

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TECHNICAL INFORMATION RELEASES

1 September 1957 – 30 November 1957

TIR	Release Date	Material Released
1-213	10 Oct. 1957	AN/FST-2 Message Label Assignments
1-214	10 Oct. 1957	System Office Recommendation (SOER #113) To Record Command Heading In ESS & SAGE
1-215	10 Oct. 1957	Required Modifications to the 1300 to 750 Converter
1-216	14 Oct. 1957	System Office Recommendation: Digital Display Changes Requiring Program Modifications
1-217	18 Oct. 1957	System Office Recommendation (SOER #159): Quick Fix To Intercept Direction Calculations
1-218	18 Oct. 1957	System Office Recommendation (SOER #143): Changes To The DCA Program to Meet Frequency Division Data Link (FDDL) Requirements
1-219	18 Oct. 1957	System Office Recommendation (SOER #146): Changes to Master Operational Recording Tape (MORT) and Data-Association Logic
1-220	18 Oct. 1957	System Office Recommendation: Interim SSTP and Variable Display Equipment (SOER's 66, 149, 224, 230, 222)
1-221	23 Oct. 1957	SAGE Air Defense Sector System Test Concept
1-222	23 Oct. 1957	Contents of the McGuire Programs (DCA, PROC, SGS, UTILITY)
1-223	22 Nov. 1957	SOR: Variable Display Equipment, Release of IBM Specifications S68 and S68-1
1-224	22 Nov. 1957	AN/FST-2 Video Quantizer and Range Gate Parameters
1-225	29 Nov. 1957	Solid State SIF Code Detector
1-226	29 Nov. 1957	Dynamic Testing of a SIF Code Detector
1-227	29 Nov. 1957	Vacuum Tube SIF Code Detector

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SYSTEM DESIGN

GROUP 61

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I. SYSTEM DESIGN
GROUP 61

A. SUMMARY

Group 61 continued its participation in the planning of weapons integration in 1959-60 SAGE. Specifications for improved manned interceptor capability were drafted and preliminary F-102 flight tests were conducted in the Cape Cod System. A draft of the specifications for the SAGE 1960 antiaircraft function was completed which includes options for less centralized control of AA battery assignment. Three simulation programs* – SNORT, CASBA-Cairo, and BISEPS II – were continued. Further modification and clarification of specifications for the initial tactical integration of the BOMARC IM-99A continued in a joint effort with Boeing, SDC, the 4620th ADW, and three Lincoln Laboratory groups.

Detailed specifications for manned interceptor capability in 1959-60 SAGE include three profiles for century series interceptors and will be published in a series of memorandums beginning with 6M-4490-1. Tests of F-102A's in the Cape Cod System did not reveal any significant tracking problems; a two-speed profile, supersonic attack, and several combinations of final turn and crossing angles were employed.

A draft of the operational specification for total antiaircraft defense in 1960 SAGE was completed. It permits SAGE to operate with both automatic and manual Army air defense command posts, and includes options for decentralized control of battery assignment.

The writing of the SAGE non-real-time (SNORT) simulation continued: Group 61 had virtually completed the SIF beacon data generation portion and was coding a new program to simulate aircraft radar data (SARD). Five hundred missile-target situations set up by two Canadian simulations, CASBA (Canadian SAGE-BOMARC analysis) and Cairo, led to recommendations for improving initial SAGE tracking logic. The writing of BISEPS II, a real-time simulation to study the operator-machine relationship in BOMARC-SAGE tactical integration, continued at IBM with Group 61 consultation.

D. R. Israel

B. MANNED INTERCEPTORS

1. Specifications for Century Series

Detailed operational and mathematical specifications for improved manned interceptor capability in SAGE were written in draft form. Three profiles were established for the F-101B, F-102A, F-104A, and F-106A, with the concurrence of the appropriate weapons contractors:

(a) Soraco (short range at co-altitude) – interceptor flies at high speed cruise at target altitude.

(b) Sorano (short range at optimum altitude) – interceptor flies at high speed cruise at an altitude selected for most efficient fuel consumption.

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* SNORT: SAGE Non-Real-Time
CASBA: Canadian SAGE-BOMARC Analysis (Cairo is a modified version of CASBA)
BISEPS: BOMARC Interceptor SAGE Experimental Computer Program

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(c) Lorano (long range at optimum altitude) – interceptor flies to target area at low cruise speed at an altitude selected for most efficient fuel consumption, accelerates to high speed at a fixed time before final turn to attack.

After review, the draft will be published under the general heading of "Improved SAGE Manned Interceptor System" in a series of memorandums beginning with a summary, 6M-4490-1.

2. F-102A/SAGE Flight Confirmation Program

In September eight flight tests were conducted in the Cape Cod System using F-102A's and live strike aircraft. The purpose of the tests was to uncover problems likely to be encountered with the F-102 and other century-series interceptors when they are introduced into SAGE. A modified Cape Cod computer program was used. For the purpose of these tests, the principal features were: a two-speed profile, supersonic attack; final-turn bank angles of 30, 45, and 60 degrees; and target crossing angles of 15, 40, and 70 degrees. The pilots were voice-controlled by the intercept directors.

The results of the tests are as follows:

total flights	16
total passes	30
hits	4
1/2 – 1 mile miss	4
1-1/2 to 3 mile miss	10
4 to 5 mile miss	10
12 to 15 mile miss	2
lock-on achieved	20

The use of a 60° bank angle in final turn was found to have two advantages: it made the aircraft easier to track because it shortened the duration of the maneuver; and it minimized the instability of the offset point because it shortened the length of the attack path. The pilots had some difficulty executing it at first, but found that it could be done without losing altitude if the automatic flight control system was employed and the after burner used. The use of 70- and 40-degree target crossing angles resulted in satisfactory interceptions, but the 15 degree angle brought the interceptor too close to the target at roll-out; the average miss-distance was 3.5 miles.

No other problems were uncovered which would prompt any significant change in the specifications for the planned integration of century-series interceptors in SAGE. The Cape Cod tests were concluded in September and no further preliminary testing is contemplated in ESS.

C. AA INTEGRATION

A draft of the specifications for the SAGE 1960 antiaircraft function was completed during the quarter. The computer program will provide the facility for coordinating Army weapons with SAGE. Considerable flexibility has been allowed for the control of AA weapons: the antiaircraft director may select one of several options for each Army air defense command post (AADCP).

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In the list below, the AA may select any one of the three options for automatic (Missile Master) AADCP's; he may select either of the last two for manual AADCP's:

(1) Centralized – Hostile: The SAGE computer evaluates the hostile threat, selects specific AA batteries to engage each hostile target, and transmits the target information and commands to each battery.

(2) Decentralized – Hostile: The SAGE computer selects and sends to the AADCP all hostile tracks in that AA defense area. Battery assignment is under local Army control.

(3) Decentralized – Friendly: The SAGE computer selects and sends to the AADCP all friendly tracks in that AA defense area. Battery assignment is under local Army control.

Additional options are included in the program under the AAD's control: Centralized-Faker, for example, could be selected for tests of the AA function.

D. SIMULATION STUDIES

1. SNORT

The SAGE non-real-time (SNORT) simulation is being written for an IBM 704 computer to examine SAGE automatic tracking and guidance functions, using first BOMARC and later manned interceptors and other missiles. The computer program is being prepared jointly by Lincoln Laboratory, IBM, and Boeing.

Group 61 is serving as a consultant to the joint group and writing the SIF beacon data generation (BDG) program. The BDG program, virtually complete at the end of the quarter, will check each beacon with each BOMARC to determine the position of the beacon returns. Up to 300 returns will then be generated each subframe and supplied to the tracking program.

The track-while-scan (TWS) portion of SNORT is presently being completed by Group 67. The radar data background for TWS was to have been generated by SDG, the simulated-data-generation program used in ESS shakedown tests. While SDG was adequate for shakedown purposes, it was not realistic enough for a simulation study; accordingly a new program, simulated aircraft radar data (SARD) was begun by Group 61. SARD will produce 50 flight paths of 8 specified aircraft types, and will simulate the position of up to 150 flights over any of the computed flight paths. It will produce radar data from up to four radars in a 1000-mile square, including random noise and errors. By the end of the quarter, about half of the program had been coded.

2. SAGE Tracking Study

A non-real-time simulation of SAGE tracking effectiveness was carried out with a computer program called CASBA (Canadian SAGE-BOMARC Analysis) written for an IBM 704 computer by a Canadian firm for the RCAF. The program uses the currently specified SAGE tracking logic and measures tracking errors for straight line and weaving targets in areas of single and double radar coverage. The evaluation of BOMARC intercept performance was not attempted by Group 61 since the missile model was based upon out-dated BOMARC specifications and was oversimplified. A study of some 400 simulated missile-target situations revealed weaknesses in the initial SAGE tracking logic. In order to examine these in more detail, a modified program called Cairo was

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written with which 100 additional situations were studied. A summary of the CASBA-Cairo tracking study* lists the following conclusions:

(a) Tracking performance is better with double than with single radar coverage, and it improves as the quality of the radar data improves.

(b) With double radar coverage, tracking deteriorates rapidly when the radar orientation errors (mean azimuth errors) exceed 0.2 degrees.

(c) Tracking performance falls off sharply for both single and double radar coverage when the standard deviation of the radar azimuth errors exceeds 0.25°.

(d) Tracking performance is not very sensitive to blip-scan ratio variations between 0.7 and 1.0 nor to moderate densities of random noise.

(e) The angular extent of a maneuver has a more direct effect on track life than the speed of acceleration with which the maneuver is performed.

(f) The standard deviation of the speed error for non-maneuvering targets is generally below 30 knots and is largely independent of speed for speeds between 200 and 800 knots.

It was concluded that a significant improvement in tracking performance for maneuvering targets could be achieved by doubling the velocity smoothing constants of the initial SAGE tracking program and by increasing the radius of the small search area from 1 to 2 miles and the radius of the large search area from 5 to 7 miles.

3. BISEPS II

BISEPS II is a real-time simulation of AN/FSQ-7 (XD-2) being written by IBM with Group 61 assistance. It is intended to verify the design of the operator-machine relationship specified in the initial tactical integration of BOMARC with SAGE and to evaluate system performance. During the quarter emphasis was placed on making BISEPS II as much like SAGE as possible: tracking logic, displays, and operator procedures were altered to this end. Group 61 began preparing simulated-data-generation tapes which will furnish radar data for the tests. Plans† were drawn up for conducting the tests and analyzing the resultant data.

E. BOMARC

The detailed specifications for the planned tactical integration of the BOMARC IM-99A in SAGE continued to be modified and clarified by Group 61. Changes were also proposed by the 4620th ADW, Boeing Airplane Company, System Development Corporation, and Groups 67 and 64 of Lincoln Laboratory. The changes are being coordinated by the System Office, Group 68. Many changes are simply for the purpose of clarification or to make the documents consistent among themselves. Others have a significant effect on operational specifications. Typical of the latter type is a proposed change which will substantially increase the guidance accuracy of

---

* To be published as 6M-5433, "A Simulation Study of the Effectiveness of Automatic Tracking in the Initial SAGE System," by E.W. Wolf, H.W. Williams, and F. Phelps.

† To be published as 6M-5490, "Test Plans for the Simulation of an Integrated SAGE/BOMARC Air Defense System (BISEPS II)," by S.J. Hauser and J. Dominitz.

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the missile: additions to the guidance equations take into account the rotation of the earth during the flight of the weapon to its target and translate this displacement into BOMARC geographical reference coordinates.

The current status of the specifications is contained in the following series of documents:

6M-4890:	"Proposed Initial SAGE/BOMARC Tactical Capability," by D.R. Israel and H.E. Anderson, 13 February 1957
-C1:	Ibid., 25 February 1957
-C2:	Ibid., 18 April 1957
-C3:	Ibid., by A.R. Shoolman and W.D. Coulopoulos (IBM), 26 November 1957
6M-4891:	"Operational Changes to the SAGE System for Initial BOMARC Tactical Integration," by D.W. Ladd, S. Litsios, and S. Benson (RAND), 4 April 1957
-C1:	Ibid., by W.D. Coulopoulos (IBM), 26 November 1957
6M-4892:	"Missile Tracking in the SAGE System for Initial BOMARC Tactical Integration," by E.W. Wolf and S.H. Goldberg, 4 April 1957
-C1:	Ibid., by S. Benson (RAND), 30 August 1957
-C2:	Ibid., by W.D. Coulopoulos (IBM), 29 November 1957
6M-4893:	"Guidance Program Changes to the SAGE System for Initial BOMARC Tactical Integration," by R.W. Shur (IBM) and A. Talkington (RAND), 24 April 1957
-1:	Ibid., by S. Benson (RAND) and A. Talkington (RAND), 8 August 1957
-1, S1:	Ibid., by W.D. Coulopoulos (IBM), 4 November 1957
-1, S1, C1:	Ibid., by W.D. Coulopoulos (IBM), 29 November 1957
6M-4894:	"General Program Changes to the SAGE System for Initial BOMARC Tactical Integration," by S.J. Hauser and J.W. Shay, 1 April 1957
-C1:	Ibid., by S. Benson (RAND), 22 August 1957
-C2:	Ibid., by W.D. Coulopoulos (IBM), 26 November 1957
6M-4895:	"AN/FSQ-7 Equipment Changes for Initial BOMARC Tactical Integration," by L.V. Ruffino (IBM), 23 April 1957
-C1:	Ibid., by S. Benson (RAND), 30 August 1957
6M-4896:	"Proposed Changes to SIF and Data Link Equipments for Initial BOMARC/SAGE Tactical Integration," by H. Anderson, J. May, and E. Wolf, 15 February 1957
-S1:	Ibid., by S. Benson (RAND), 30 August 1957

ESS INSTALLATION

GROUP 62

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II. ESS INSTALLATION
GROUP 62

A. SUMMARY

Equipment performance in the Experimental SAGE Sector (ESS) Direction Center improved noticeably in shakedown and evaluation tests following an intensive search for malfunctions during the last week in October, when test operations were suspended. Modifications of the long-range radar input channels increased their ability to reject bad parity messages and to prevent the channels themselves from generating bad parity messages. The first step to install the 65,000-register core memory was taken with only minor changes to the computer being made.

Montauk and Bath height finders each participated in one closed loop error-rate test: 90% or more of the height comparisons were correct within ±250 feet. Aircraft were tracked by search,height finder, and Mark X radars at Bath, Montauk, and S. Truro using the single-track tracking program: range errors were 1/2-mile or less and azimuth errors were insignificantly small. Unexplained errors in the height returns were observed which could not be correlated with data from previous tests, and a reappraisal of the subsystem design was considered necessary before further height finder testing by Group 62 could be of value.

Pre-mission test programs for all ESS subsystems except crosstell were recorded on a tape and furnished with a single-card control program. A system of real-time programs was planned which will diagnose certain computer equipment failures while the DCA program is operating and, in some cases, take corrective action.

J.A. O'Brien
W.J. Canty
R.S. Fallows

B. COORDINATION OF ESS MAINTENANCE

Group 62 serves as liaison between the users of ESS and those responsible for maintaining ESS equipment. It is primarily a service organization whose function is to provide ESS users with a system that has been tested for use and has the desired program operating in the computer. Its activities depend upon test programs, special test equipment, a reliable method of locating equipment malfunctions, and the facilities and cooperation of all equipment and user groups. Problems of larger scope may be taken under long term study in cooperation with IBM.

1. AN/FSQ-7 (XD-1) Operation

In the last week of October evaluation and shakedown tests were postponed so that problems encountered in computer operation could be isolated and eliminated. Important sources of error were found in the drum system, particularly in the drum heads that were coated with dirt. The drum system was studied in detail and it was decided that intensified maintenance would keep the performance of the computer at a high level. Improved equipment operation was observed when shakedown and evaluation tests were resumed on the 31st of October.

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2. LRI Modification

The long-range radar input (LRI) channels were modified to increase their ability to recognize and reject bad parity messages and to prevent the channels themselves from generating bad parity messages (see Fig.62-1). The modifications prevent noise from entering the channel during the sync format; prevent a new message from entering the channel while the channel is fast shifting; prevent fast shifting while the channel is writing on the drum; and make the parity indication circuitry indicate correctly for all cases. Performance of the LRI frame was significantly improved by these modifications.

Fig. 62-1. Long-range radar inputs. Data from the long-range radars is received in the frame at the extreme right after being decoded by the digital data receivers. Each channel in the LRI frame converts each message to parallel form as required by the computer. The actions of the LRI frame are modified by the plug-in units in the center of the photograph to prevent the generation of bad parity messages (see text). The data is then transferred to the computer and simultaneously monitored and displayed by the LRI Monitor on the left and scope in the foreground.

The mapping supervisor, with a similar display in the mapping room, monitors the operations of the mappers at the radar sites and evaluates the quality of the incoming data.

3. 65,000-Register Core Memory

The first of five steps to install the 65,000-register core memory in AN/FSQ-7 (XD-1) was taken in November. Several minor hardware and internal logic changes were made to the computer during assigned installation time and were tested for satisfactory operation before returning the machine to the users. No changes to the air defense program are contemplated until 1958.

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C. SUBSYSTEM INTEGRATION AND MAINTENANCE PROCEDURES

The coordination activities reported above are supported by programs and techniques designed to test remote equipment from the direction center in a series of subsystem tests. Programs and maintenance routines are also prepared to verify the proper operation of equipment after it has been installed in the direction center.

1. Radar Inputs Tests

Height finder error-rate tests were conducted once with Montauk and once with Bath. Each test consisted of a closed loop of computer generated requests and site replies which tested the AN/FST-2, the range-height indicator, and the input-output equipment at the sites and at the direction center. In both tests, 90% or more of the comparisons between the sent heights and received heights were correct to within ±250 feet.

Aircraft were tracked with the single-track tracking program by the long range, height finder and Mark X radars at Bath and Montauk, and the height finder at S. Truro. Range errors in the long range radar returns were 1/2-mile or less, while azimuth errors were too small to be significant. Unexplained errors in the height returns were observed which could not be correlated with data from previous tests. Because of the inconsistency of the variations in height returns, the test team has found it impossible to isolate error sources, and further testing is considered inadvisable until the design of the subsystem is reappraised.

2. Pre-mission Equipment Tests: ECO

Pre-mission tests for teletype outputs and status drums were added to the equipment checkout (ECO) program. The entire system of test programs was then recorded on magnetic tape from which any desired routine can be selected by a single-card control program. Thus, all ESS subsystems except the crosstell output are now included in a simple, versatile system which enables the maintenance coordinator to quickly verify the operational status of ESS subsystems before shakedown or evaluation tests. The ECO program now includes tests for:

(a) long range, gap filler, and height finder radars,
(b) ground-to-air, frequency-division data link communication,
(c) teletype outputs,
(d) manual inputs.

A visual indication of the success or failure of the tests for gap filler, long range, and height finder radars is presented on the maintenance coordinator's situation display scope (see Fig. 62-2).

a. Crosstell Test Program

A program was being written to test the crosstell input element. It will indicate the operational status of the crosstell equipment and will provide a means for delayed diagnostic action, if necessary.

b. Teletype Test Program

A teletype test program was incorporated into ECO which verifies all 25 teletype channels and checks all characters at all burst counts. Fort Banks and Montauk Point will be included in the pre-mission teletype test in the near future.

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GROUP 62

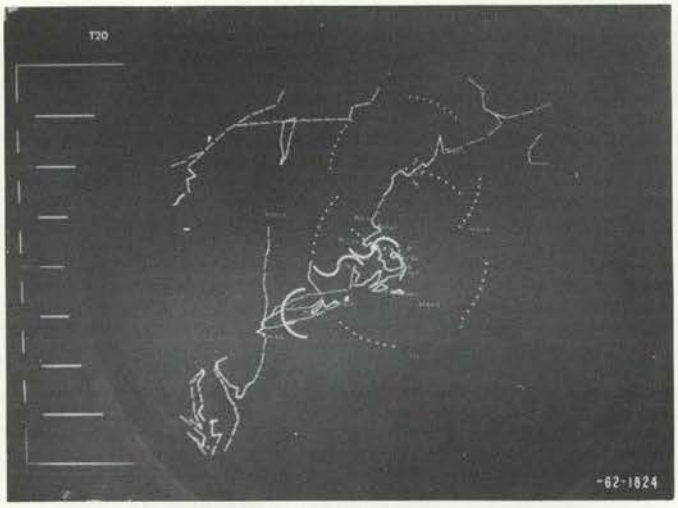

Fig. 62-2. Radar checkout display. The symbols indicate that data is being received satisfactorily at the direction center. Solid lines (semicircular or S-shaped) indicate gapfillers, dotted rings long range radar, and the small, solid circles and squares height finders. The maintenance coordinator may select any site for display individually, if he desires.

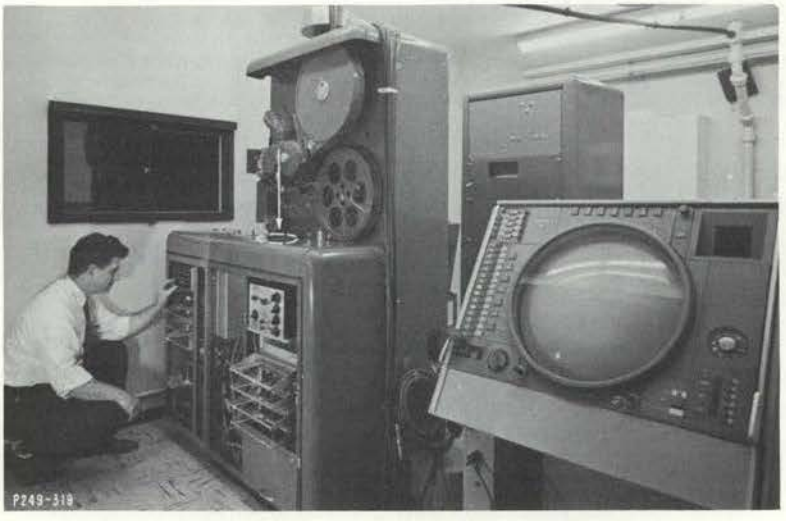

Fig. 62-3. Kelvin & Hughes projector and monitor. The operator is adjusting the setting of a new display circuit which provides a more consistently accurate positioning of the characters on the 5" display tube (arrow).

3. UDA: A Diagnostic Program for the DCA Program

The design was begun of a system of programs which will diagnose computer equipment failures while operating in real time with the DCA program. In the event of a failure, the Utility Diagnostic Active (UDA) System will attempt to locate the trouble, correct it whenever possible, and restore the system to normal operation. Representatives of the RAND Program Development Group, IBM, and Group 62 developed preliminary logic for a control program in flow diagram form and began to design programs which will detect parity errors in drum or core memory and take appropriate action automatically. For example, a core memory parity or overflow condition will initiate automatic startover of the DCA program. A status drum parity will cause the entire message in error to be reset to negative zero in the core; the field in error will be listed in a learning table if there is no previous record of the error; and an audible alarm will call attention to a digital display indicating the field, identity, word in error, number of errors this transfer, and total number of all errors this test.

The UDA system is being designed to operate specified functions at any appropriate time in the DCA cycle; e.g., after every program unit, after every subframe, or after every in-out transfer. The principal components of the UDA system will be:

(a) UDC: a control program that will call in and operate any UDA program.

(b) UDR: a program that will record information during the operation of the DCA program.

(c) A series of selectable diagnostic and/or recovery programs.

D. EQUIPMENT DESIGN SUPPORT

Special equipment, mainly for test purposes, is designed and built in support of the integration and maintenance activities reported above. The maintenance of Lincoln Laboratory power supplies is coordinated.

1. Kelvin & Hughes Camera-Projector

New circuits continued to be installed which will provide more consistently accurate positioning of characters on the 5-inch situation display scope. In order to avoid interruption of the command post functions during ESS shakedown tests, the new circuits were assembled separately so that either the new or old circuits could be used (see Fig. 62-3).

2. Input-Output Tape Recorder

An additional Ampex FR-100 tape recorder was received and a preamplifier was built for it. The system is used to record phone-line data and telephone conversations during ESS shakedown tests. At a tape speed of 7.5 inches per sec., one reel yields three hours of continuous recording.

3. Additional Power for ESS Direction Center

To satisfy increasing demands for electrical power in the ESS Direction Center (Building F), a 500 KVA load center was ordered for installation in the spring of 1958. As a temporary measure, a 150 KVA transformer was added to the original 150 KVA load center in November. Most

of the increased demand comes from a newly installed data processing room which contains card machines, line printers, and tape units. Additional d-c supplies for general use are planned for future installation.

E. AN/FSQ-7 (XD-1) PERFORMANCE

AN/FSQ-7 (XD-1) performance, less displays and manual inputs keyboards, but including input-output equipment, was as follows:

Total Computer Hours	821.43
Per Cent Good Time	86.1
Mean Free Time (Hours)	8.5
Average Lost Time per Interrupting Incident (Hours)	1.3

ADVANCE DEVELOPMENT

GROUP 63

PAPIAN, W. N., *Leader*
CORDERMAN, C. L., *Associate Leader*
GOODENOUGH, J. B., *Associate Leader*

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BARCK, P. E.
BEHRNDT, K.
BEST, R. L.
BRADSPIES, S.
CLARK, W. A., JR.
COWGILL, URSULA M.
CROWTHER, T. S.
DAVIDSON, G. A.
DOWNING, J. L.
DUGGER, C. O.
DWIGHT, K., JR.
ECKL, D. J.
ELLIS, D. H.
EPSTEIN, M. A.
FADIMAN, J. R.
FARLEY, B. G.
FERGUS, PATRICIA A.
FERRETTI, A.
FLETCHER, J. W.
FORGIE, J. W.
FOWLER, P.
FRANKOVICH, J. M.
GILMORE, J. T., JR.
GOULD, R. H.
GUDITZ, E. A.
GURLEY, B. M.
HERNDON, T. O.
KIRK, C. T.
KONKLE, K. H.
LARSON, E. G.
LOEB, A. L.
MADDOCKS, F. S.
MENYUK, N.
MITCHELL, J. L.
NEUMANN, L.
PETERSEN, M.
PETERSON, H. P., JR.
RAFFEL, J. I.
SARLES, F. W.
SAVELL, R. E.
SMITH, D. O.
UNDERWOOD, D. I.
WEISS, G. P.
WICKHAM, D. G.
WILLIAMS, H. W.
WOLD, A.
ZIEGLER, H. L.
ZIEMAN, H. E.
ZOPATTI, R. C.

III. ADVANCE DEVELOPMENT
GROUP 63

A. SUMMARY

The first of two transistor-driven core memories (TDCM) now under construction will be installed in TX-0. Twenty-one acceptable planes have been produced, 3 of which have been wired into the memory stack. Some of the difficulties with the operation of the core test handler for the 50-mil O.D. by 30-mil I.D. cores used in the TDCM have been eliminated. During a six week period, in which the handler required only nominal maintenance, 126,000 cores were tested.

Design modifications to TX-2 circuits have been stimulated by new graded-base transistors which were not available a year ago. The new transistors have been used extensively in the circuits of the X-(index) memory, e.g., the read and write drivers, carry circuit inverters, and the pulse amplifier and register driver.

A breadboard model of a high-speed, random-access tape drive is under test for the TX-2 experimental computer. Three-phase motors pull the tape in either direction without a capstan drive. A permanently recorded timing track provides a speed reference for motion control and generates timing pulses for both read and write.

A light pen and display system for the TX-0 experimental computer have been constructed with which one can "type" on a 200-character keyboard display. This equipment is to be used initially to determine the type and location of keyboard characters best suited to the needs of TX-2 programmers. When this information is obtained, the specifications for a special keyboard will be written.

Final tests are in progress on a remote system to reproduce, at Lexington, displays generated by Whirlwind I at Cambridge. A WWI computer program has been written to display a numbered 14 × 14 array of random alphanumeric characters for legibility studies.

A thin film pulse tester has been built to index, drive, and sense the individual spots of an 8 × 8 array. The output of a thin film can be sensed with an over-all delay of about 45 millimicroseconds by means of a differential amplifier using graded-base transistors.

An appendix to this report to be found on page 27 presents the summary of progress of the Magnetic Materials Section of Group 63. The complete report will be found in Lincoln Laboratory Quarterly Progress Report (1 September to 1 December 1957) Solid State Research. Groups 24, 35, 37, 63, 310 (Unclassified).

W. N. Papian
C. L. Corderman
J. B. Goodenough

B. MEMORY

1. TDCM

Although assembly of planes for the transistor-driven core memory (TDCM) was limited by a lack of tested cores, enough progress was made to justify assembly contracts with A. J. Koch and RCA (Needham, Mass.). By the end of the quarter, 21 planes had been accepted and 3 had

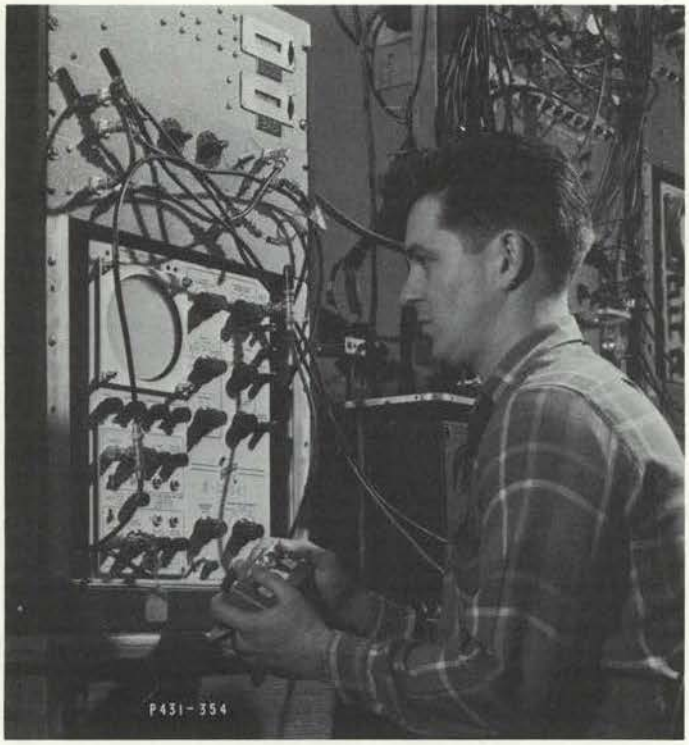

Fig. 63-1. Testing 50-mil O.D. by 30-mil I.D. ferrite cores for transistor-driven core memory (TDCM).

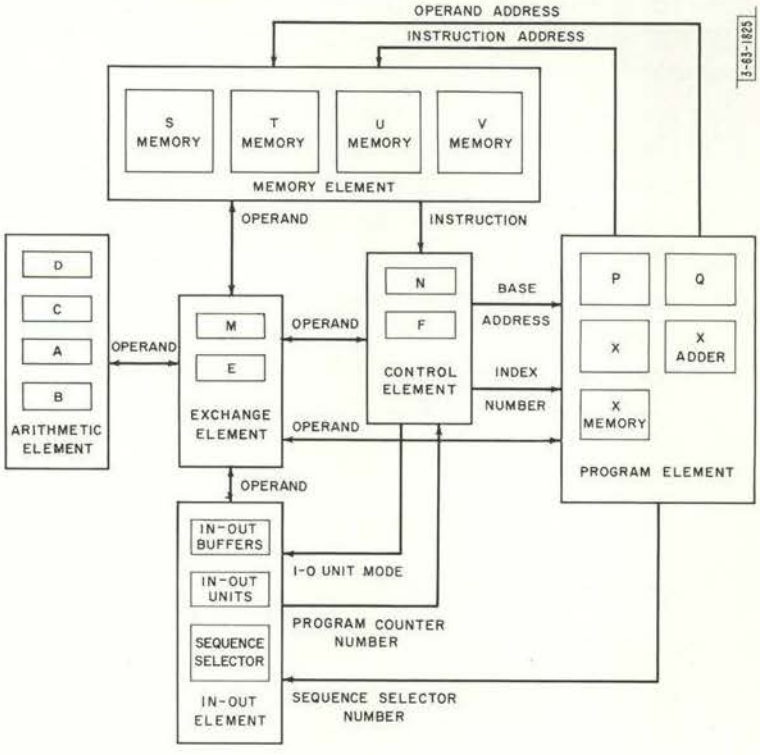

Fig. 63-2. TX-2 system schematic.

been wired into the memory stack. Power supplies for the TDCM are being built and a detailed investigation of the driving circuitry is being conducted.

2. Core Test

The revised model of the first core handler for 50-mil O. D. by 30-mil I. D. cores has not yet been brought to a satisfactory point. High-speed movies taken of the core handler showed where and how cores were breaking at the end of the track. After this problem had been corrected, the core handler was used to double-test cores at the rate of 4200 per day for about six weeks with only nominal maintenance. After that, accumulated wear on critical parts necessitated a complete overhaul. Two other core handler models are being evaluated.

C. TX-2

1. Equipment Installation

Prototypes of the various plug-in units for the toggle switch storage in TX-2 have been made and the back panel is being wired. The toggle switch storage uses a resistor matrix and has a capacity of twenty-four 36-bit words. Both halves of the A, B, C, and D registers are now mounted on the frame (see Fig. 63-2) and a large portion of the interwiring of these registers is completed. The M and N memory buffer registers with their parity-count circuits and register drivers have been wired and checked. The P, Q, and CS control counters have been wired in and checked. Large parts of the memory-element, memory-inhibit, and selection circuits are complete. The X-memory has been run and tested in conjunction with the control sequence counter. The counter and its control circuits have been tested and are working properly. Several modifications have been made on the X-memory circuits (Fig. 63-3) to take advantage of

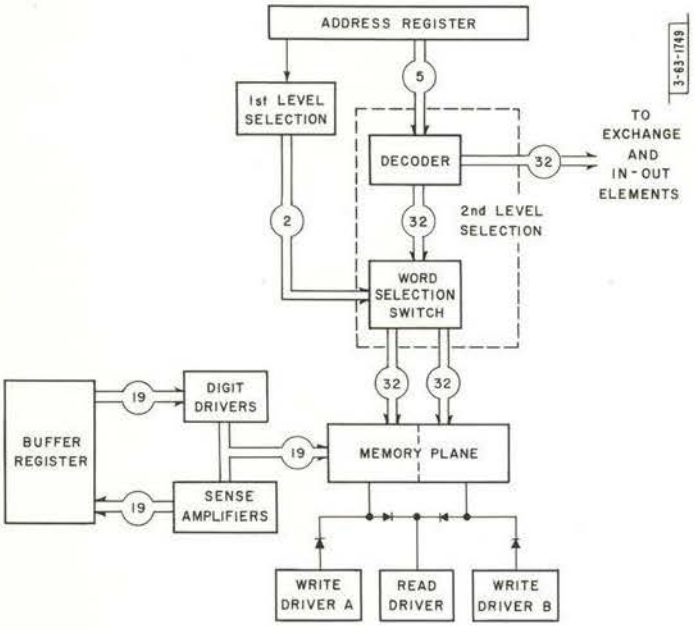

Fig. 63-3. Block diagram, X-memory.

GROUP 63

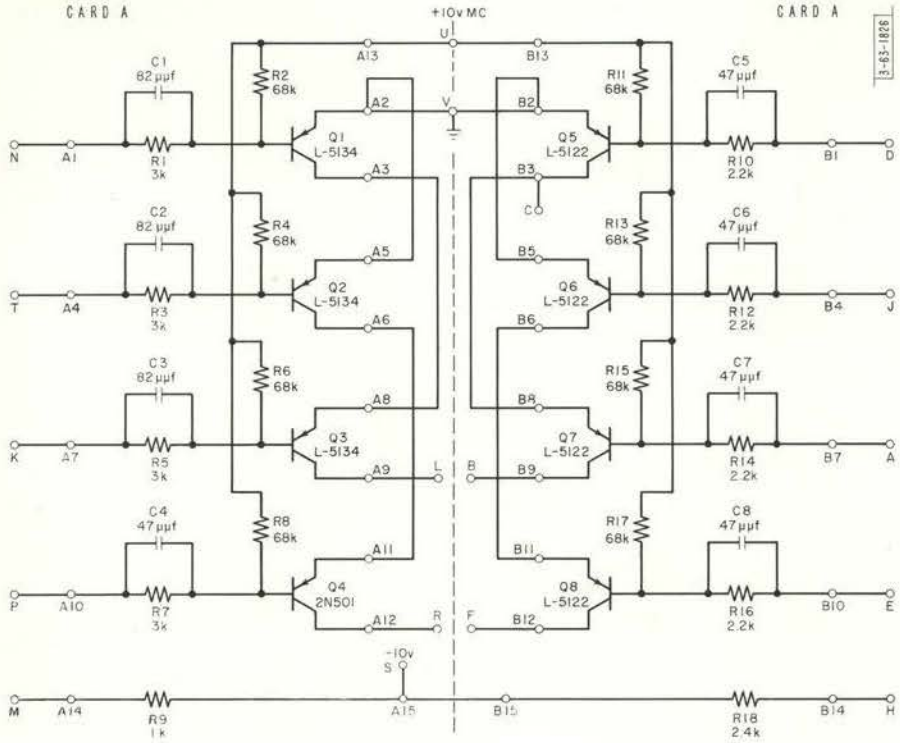

Fig. 63-4(a). X-memory, inverter, new design.

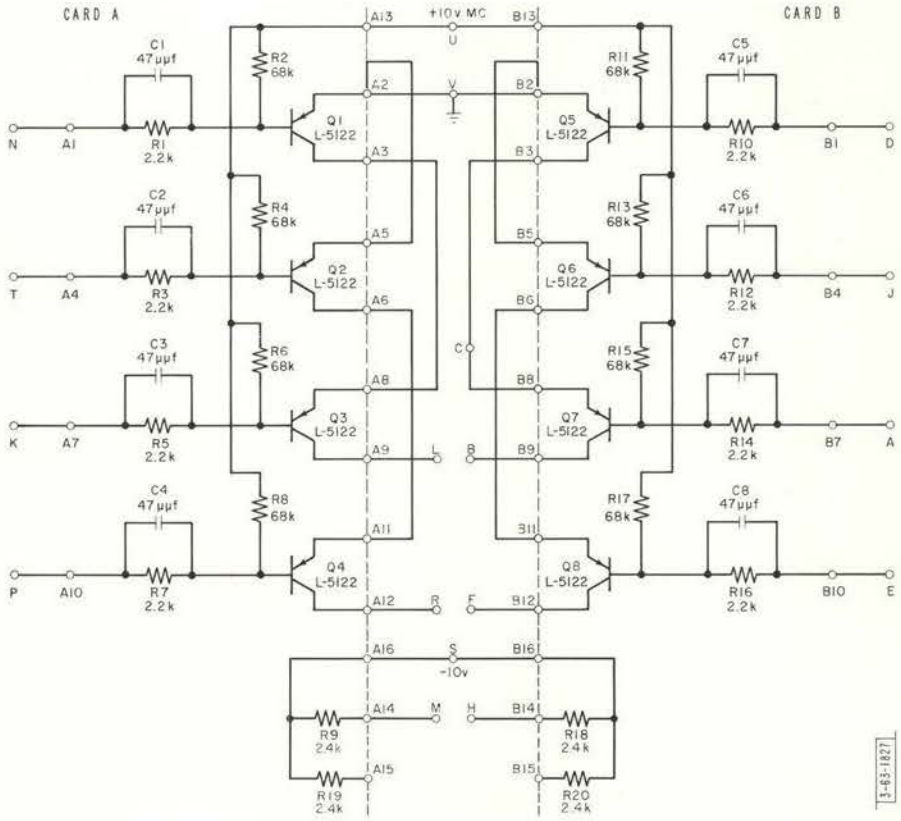

Fig. 63-4(b). X-memory, inverter, original design.

the Philco L-5409 (EIA type 2N501) graded-base transistors which have become available since the original circuits were designed a year ago; as a result operating times have been reduced by several tenths of a microsecond and the number of components reduced. Among the circuits which have been changed are the following: (a) X-adder carry circuit, inverters (Fig. 63-4(a, b)); (b) X-memory read driver (Fig. 63-5(a, b)); (c) X-memory write driver (Fig. 63-6(a, b)); (d) pulse amplifier and register driver.

2. Tape Drive

The design and construction of a high speed tape machine with random access for TX-2 continued through the quarter. Two conventional 3-phase motors pulling in opposite directions are used instead of a constant speed capstan to drive the tape. A ten-track head was installed which will allow reading and writing to be done from the same head assembly at the same time. There will be a permanently recorded flux pattern redundantly paired on tracks 1 and 10, which will generate timing pulses to be used for both read and write. Tracks 2 and 8 are left out to provide isolation from the write noise generated in the other tracks, leaving three redundant pairs of tracks for information. The timing pattern will also be used to control the tape which thus becomes a fixed address memory. The timing pulses are delayed so that information flux patterns go on the tape in phase with the permanent flux pattern of the timing track to permit the replacement of any message with another of the same length. A breadboard model of the tape drive with a 0.5 mil gap head was constructed and is under test.

3. Programming

A number of practice programs for TX-2 have been used to evaluate and modify the operation code and to anticipate the problems likely to be encountered in the writing of the utility system. If the full versatility of the TX-2 is to be realized, instructions will be required to indicate such things as configuration control, index registers, indexable addresses, indirect or deferred addresses, the amount to increase or decrease index registers, and the means of sensing or setting individual bits in a given register. These problems do not exist when TX-2 is used as a 36-bit fixed word length machine. However, the speed and versatility possible with configuration control will encourage more sophisticated programming. In order to formulate a technique or method by which to express the various capabilities of each instruction, a new typewriter keyboard is being investigated with the aid of a TX-0 simulation program. The characters on the displayed keyboard can be changed by a light gun pen which will be discussed in the following paragraphs. The typing itself may be done by the light pen and the characters will appear on an oscilloscope.

D. TX-0

A light pen with built-in amplifier for use with TX-0 has been constructed and a simulated 200 character keyboard typewriter (scope writer) is now working. Several programs have been written which allow the operator to "type" on the keyboard which is displayed on the oscilloscope. With the light pen and the scope camera a choice will be made of characters and symbols best suited for the transfer of information between the programmer and the computer.

GROUP 63

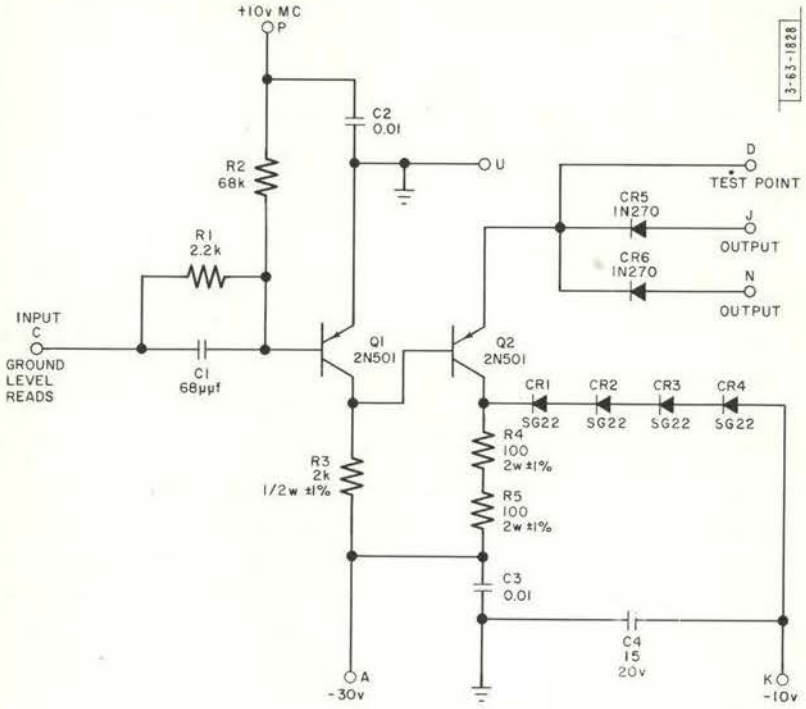

Fig. 63-5(a). X-memory, read driver, new design.

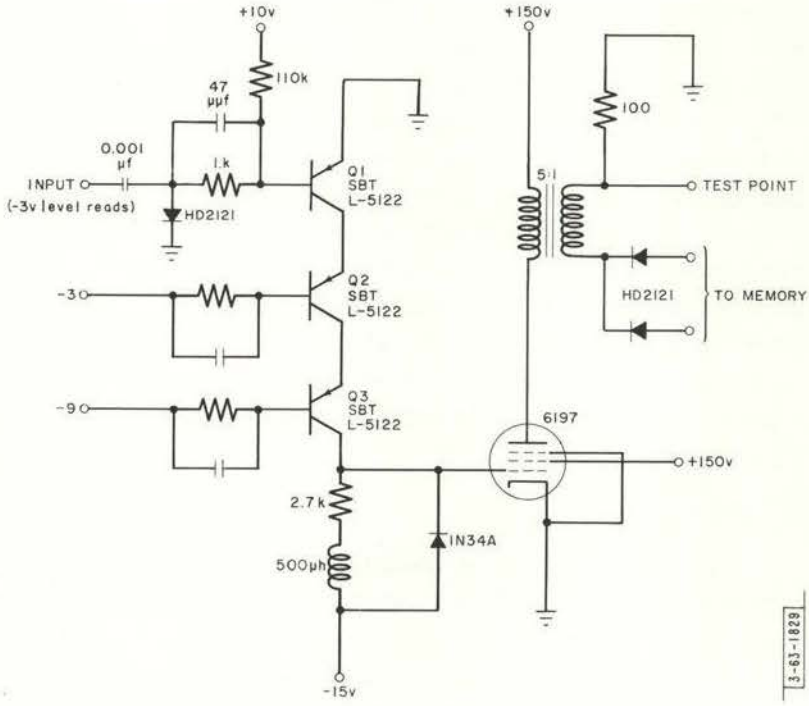

Fig. 63-5(b). X-memory, read driver, original design.

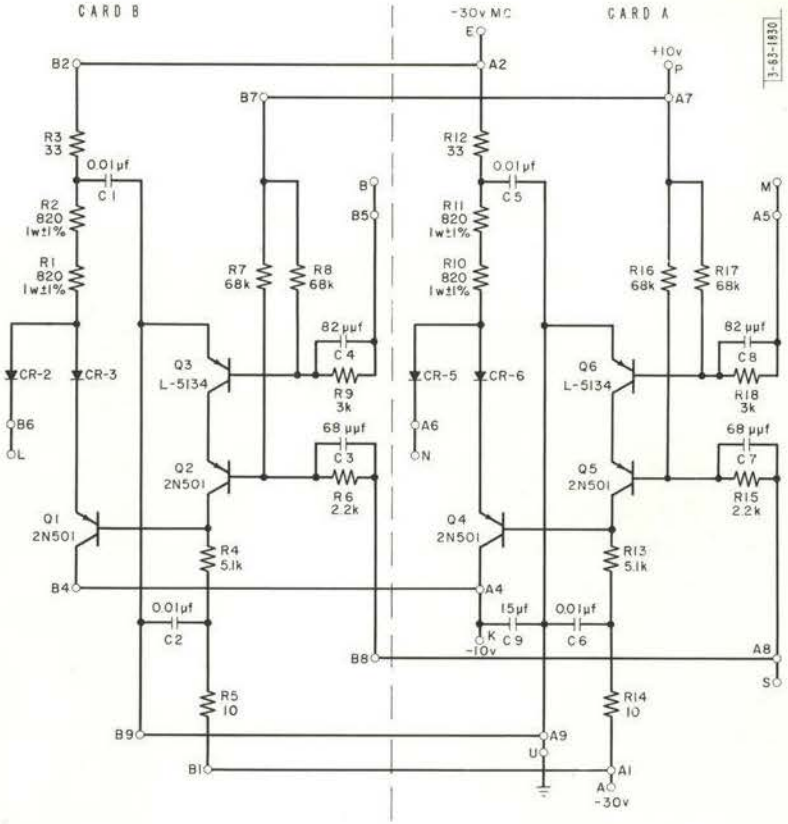

Fig. 63-6(a). X-memory, write driver, new design.

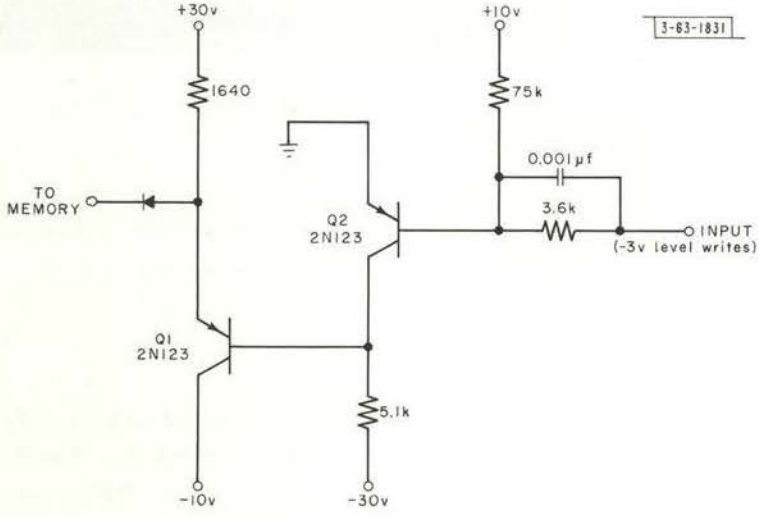

Fig. 63-6(b). X-memory, write driver, original design.

GROUP 63

E. DISPLAY

The remote display equipment* has been undergoing final tests. An annoying background flicker on the face of the tube was traced to two sources: a fairly large amount of 60-cycle ripple on the storage mesh and a beat note between this 60-cycle ripple and the erase frequency. The problem was cured by changing the erase frequency to get all of the beat notes beyond visual perception and further filtering the storage mesh power supply to reduce the 60-cycle ripple.

A revised WW I program has been written to produce a suitable display for the legibility studies which will follow. The program will display a numbered 14 × 14 array of random alphanumeric characters once every 15 seconds; each character will be repeated six times and shifted by the space of half a character each time. This should show the overlap problem at its worst and will permit the adjustment of the memory time of the tube to minimize the overlap confusion. The message will be transmitted from WW I to Lincoln by a telephone line and will be displayed and recorded on magnetic tape for later playback. A printout will be available from WW I to verify the accuracy of the displayed message.

Fig. 63-7. Thin film evaporating unit with major elements identified.

F. THIN FILM ENGINEERING

1. Thin Film Tester

A thin film pulse tester and handler has been built to index 8 × 8 arrays of thin film spots and has been used to drive and sense the individual spots of such an array.

The first thin film memory will be built to store machine configurations in the control element for TX-2. It will have a capacity of thirty-two 10-bit words (1 parity bit), and a cycle time of between 0.5 and 1.0 microseconds.

2. Sense Amplifier

A differential amplifier for sensing film outputs was designed and constructed using L-5409 graded-base transistors. The gain of the amplifier is fairly flat from 1 to 10 megacycles and falls approximately 2.3 db at 20 megacycles. The actual gain figures per half of the difference amplifier are 120 db from 1 to 10 megacycles and 75 db at 20 megacycles. The circuit produced an output of approximately 0.3 volts from the 0.003 volt input provided by the thin film test memory. Rise time appeared to be on the order of 0.8 microseconds.

*Quarterly Progress Report, Division 6, Lincoln Laboratory, M.I.T. (15 September 1957) Sec. III.D.

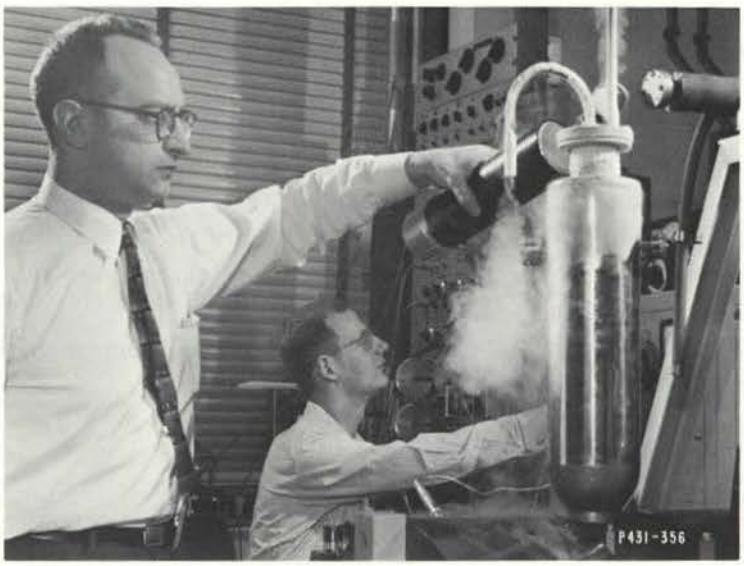

Fig. 63-8. Investigating magnetic properties of thin films with the vibrating coil magnetometer. Liquid helium is used to maintain the temperature of the test chamber close to absolute zero. In the photograph the vapors escaping from the gooseneck show that the helium is satisfactorily enclosing the test chamber. Liquid nitrogen is being added to the Dewar to retard evaporation of the helium. When the test chamber reaches the proper temperature as determined by the thermocouple gauges being read on the control panel in the background, the thin film test sample, attached to the end of a glass rod, is lowered gradually into the test chamber located between the poles of an electromagnet.

The use of the differential amplifier for sensing film outputs has greatly reduced the digit driver transients that appeared to be a serious threat to short memory cycle times. The shortest delay time for the entire logic has been about 45 millimicroseconds. An evaluation of over-all circuit characteristics is planned for the next quarter.

APPENDIX
SUMMARY OF MAGNETIC MATERIALS SECTION*

This report covers the period from 1 September through 30 November 1957.

VII. Magnetic Materials*

Work has continued on the problem of obtaining a deeper understanding of the relationship between chemistry and the fundamental, intrinsic properties of magnetic materials. The theoretical concepts based on the relative symmetry of the d wave functions of transition-element cations and their near-neighbor coordination has led to a better qualitative understanding of

*cf. Lincoln Laboratory Quarterly Progress Report, Solid State Research, Groups 24, 35, 37, 63, 310, 1 February 1958.

crystallographic and magnetic properties of many oxides. As part of a program to both investigate new magnetic materials and test out the qualitative predictions of the theory with experiment, several new spinel-type and perovskite-type oxide systems have been investigated. A start has been made to extend these theoretical ideas to the complex problem of magnetic metals and alloys.

The development of immediately practical materials has provided the microwave people with a ferrite which has a 40 oe. line width at L band. Work on the thermistor material $NiMn_2O_4$ has suggested the probable mechanism responsible for the low resistivity as well as that responsible for the thermistor action in these materials.

The vibrating-coil magnetometer has proven a useful instrument for the investigation of an interesting transition in a single crystal of $Ni_{0.79}Fe_{2.26}O_4$ at 10°K.

VIII. Thin Magnetic Films

The principal problems connected with the development of practical components from evaporated films of permalloy are (1) an understanding of the static and dynamic characteristics of magnetic films, (2) control of the magnetic anisotropy, and (3) control of the uniformity of films during fabrication of extensive arrays and between preparations. The first of these problems has now been extensively investigated; the results are not only important for engineering purposes, but are also interesting for a clearer understanding of the true character of the dynamic equation of motion for spin systems in magnetic materials. Work continues on the second of these; it is motivated largely by the suspicion that the origin of the uniaxial anisotropy in these films is associated with the magnetostriction, the effect magnified by the large internal stresses which are present in thin films of material. Work on the third problem has had to await the equipping of a small chemical laboratory.

IX. Transistors

Work with transistors continues to concentrate on the evaluation of currently available transistors from industry, especially of those transistors which are currently being used in the TX-2 computer. Results of these evaluations, theoretical and experimental, are used not only for the selection of the optimum components commercially available for engineering use, but also as a feedback to the commercial supplier so that further improvements in transistor design for computer applications can be achieved.

ESS SHAKEDOWN TESTING – WWI AND MTC OPERATION

GROUP 64

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BRIDGE, H. P.
BROOKS, EMY P.
BRYAN, JEAN C.
BUZZARD, R. D.
CASE, A. W.
CHOMSKY, CAROL S.
DECOF, D. N.
EARL, LOIS M.
FITZPATRICK, VIRGINIA
GATES, E. K.
GILL, E. P.
GILLIS, C. V., JR.
GRANDY, C. C.
HEALY, L. D.
HODDER, J. C.
HOLMES, L. L.
HOPKINS, F. W.
HUGHES, A. D.
JOHNSON, T. G.
JONES, N. T.
KINNEY, G. C.
LAFFERTY, E. L.
LIN, C. S.
MERCER, H. F.
MONAHAN, J. H.
MORRISON, D. A.
MURPHY, P. J.
NICHOLS, J. R.
NORCOTT, L. H., JR.
OCKENE, N. J.
PETRINO, A. R.
REED, G. C.
ROBERTS, J. E.
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ROWE, A. J.
SCHIMELFENYG, D.
SLAGLE, J. R.
SMALL, C. E., JR.
STOCKEBRAND, T. C.
THOMAS, D. J.
VANDERBURGH, A., JR.
WOODWARD, W. B.

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IV. ESS SHAKEDOWN TESTING – WWI AND MTC OPERATION GROUP 64

A. SUMMARY

Phase II of shakedown testing in the Experimental SAGE Sector (ESS) began on 1 October. Evaluation tests of the system began at the same time: Group 64 ran the tests and Group 22 evaluated the resulting data. The principal objectives of Shakedown Phase II are to verify the latest model of the air defense program, integrate additional radar sites, improve operator proficiency, and correct any malfunctions in the system. A memorandum summarizing the achievements of Shakedown Phase I was published as 6M-5384. The Memory Test Computer (MTC) continued its support of ESS shakedown testing by reducing test data for analysis and producing simulated-data-generation tapes. The maintenance of Whirlwind I (WWI) was continued.

Thirty-three test periods were held, eighteen of them involving live aircraft. Model O, the first revised version of Package D of the direction center active (DCA) program was used beginning in October and by the second week in November was free enough from errors to be used in evaluation. The Montauk radar site was integrated after the accuracy of the height, search, and Mark X data was found to compare favorably with the other heavy radar sites. Four gap filler radar sites participated in four tests; preliminary examination of the data indicated that two gap fillers register within one mile of the data from the three long-range radar sites. The relatively large amount of track data received from the gap fillers creates a display problem and will be the object of special study.

E. S. Rich
N. L. Daggett

B. STATUS OF THE SHAKEDOWN PROGRAM IN ESS

On 1 October 1957 Group 64 began Phase II of shakedown testing in the Experimental SAGE Sector (ESS). As of that date the operational and mathematical specifications of the system had been implemented and an operational sector for the start of evaluation testing had been provided. During Phase I of shakedown, which began on 3 December 1956, the major components of the system were brought together at the conclusion of their component or subsystem testing; incompatibilities between them were identified and removed; defects which hindered or prevented successful system operation were diagnosed and corrected; operator proficiency was developed; and operating procedures were established. Thus the major objectives of Shakedown Phase I have been achieved. A memorandum* was published which describes each essential part of ESS – its equipment, program, and operators – reviews the development of each during the first 10 months of shakedown, and summarizes the status of the principal air defense functions contained in the program.

Testing in ESS during Phase II continues at the rate of three test periods per week: one for shakedown, one for evaluation, and one for training ESS operators and Air Training Command (ATC) instructors. Evaluation tests are conducted by Group 64: the resulting data is evaluated

* 6M-5384, "ESS Shakedown Testing: Summary Report (3 December 1956 – 30 September 1957)," E.S. Rich, 16 October 1957.

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Test No.	Standard Input Data	Times Performed	Primary Functions Tested
		SHAKEDOWN	
18	Mixed	2	Weapons direction
19	Mixed	2	Similar to #18
20	Live	4	Entire system; full scale comprehensive air defense tests
21	Live	3	Similar to #20
II,1	Live	2	Gap filler radar inputs
II,3	Ampex/ Simulated	1	Gap filler and long range radar inputs
		OPERATOR INTEGRATION	
OIST-1*	Simulated	1	Tracking, identification, and TBS
OIST-5*	Simulated	3	All sections, moderate load (65 tracks, 20 interceptors)
OIST-6*	Simulated	5	All sections, moderate to heavy load (75 tracks, 20 interceptors)
OIST-7*	Simulated	5	All sections, heavy load (70 tracks, 40-80 interceptors – Supp #1; 70 tracks, 56 interceptors – Supp #2)
Special	Various	3	Operator integration
		EVALUATION (Objective: to measure the performance of the entire system)	
I,1	Live	1	10 straight lines strike penetrations; 15 interceptor sorties; 5 simultaneous interceptions
I,3	Live	1	10 strike penetrations, turning and splitting; 25 interceptor sorties; 5 simultaneous interceptions
I,6	Live†	1	15 strike penetrations, turning; 22 interceptor sorties; 10 simultaneous interceptions
I,8	Live†	1	15 strike penetrations, turning, splitting, and crossing; 30 interceptor sorties; 10 simultaneous interceptions
I,9	Live†	1	20 straight line strike penetrations; 30 interceptor sorties; 15 simultaneous interceptions.

*Operator integration shakedown test.

†Except 5 strikes simulated.

Fig. 64-1. ESS system tests performed, 4 September – 29 November.

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by Group 22 and will be released in a series of quarterly Technical Memorandums, beginning with TM-66-1.

The principal objectives of Shakedown Phase II are:

(1) to verify Models of the DCA program as they become available

(2) to integrate the Montauk radar site

(3) to integrate four gap filler radar sites (Scituate, Chestnut Hill, Halibut Point, and Derry)

(4) to integrate the Texas Tower II long range radar when it becomes operational

(5) to improve operator proficiency

(6) to diagnose and correct malfunctions found during shakedown and evaluation testing.

It is expected that the objectives of Shakedown Phase II will be met in six to eight months.

C. ESS SHAKEDOWN TESTING ACTIVITIES

1. Test Implementation

Thirty-three test periods were held during the quarter: 14 were shakedown (13 using live aircraft), 14 were training, and 5 were evaluation (all using live aircraft). The tests performed are described in Figure 64-1, and a breakdown of ESS testing time is given in Figure 64-2.

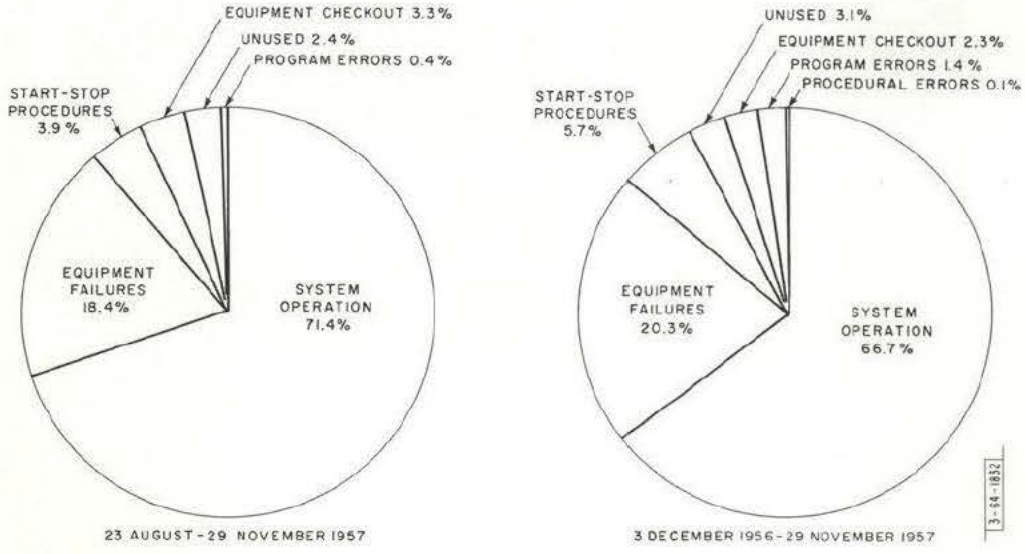

Fig. 64-2. Breakdown of ESS system testing time.

a. Direction Center Equipment

Testing during October was hampered by computer equipment difficulties. Only four of ten tests attempted were not seriously affected by malfunctions. For this reason the last three tests in the month were cancelled and the time was devoted to locating error sources in direction center equipment. As a result, operation improved considerably and 11 tests were conducted during November.

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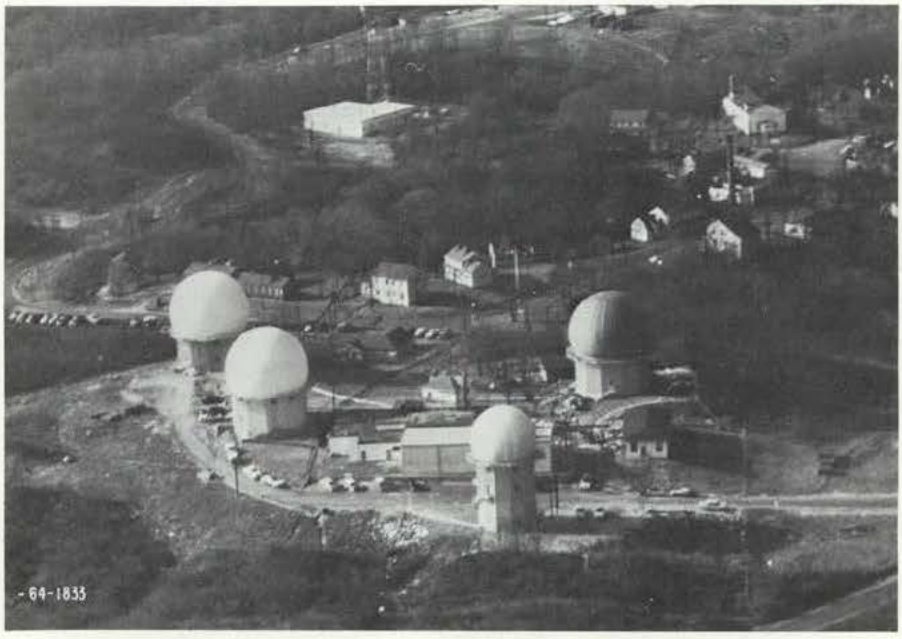

Fig. 64-3. Montauk radar site. An ADC site at which Group 21 has three men assisted by three AF men. The two large domes on the left contain height finders, the large dome on the right an FPS-20 long range radar, and the small dome an FPS-8 standby long range radar. For ESS testing, a simplex FST-2 in the building behind the FPS-20 is operated by Group 21. A duplexed FST-2 for SAGE operation is in the smaller buildings in the foreground. The large building contains a manual air defense center. Communications are furnished by UHF and VHF radio (small building at top of photo) and tropospheric scatter (not shown). The larger white building in the middle background is an AT&T microwave relay station.

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b. Radar Sites

One long range radar and one semiautomatic height finder at Montauk were integrated into ESS. Shakedown testing of this facility was completed in November and it was released for use in evaluation tests. During November four system tests of gap filler radars at Scituate, Chestnut Hill, Halibut Point, and Derry were conducted.

c. Computer Program

Model O, the first revised edition of Package D of the DCA program, was introduced to shakedown testing in October. It contains all air surveillance and weapons direction functions, but not the crosstell function. After a number of errors were corrected the program operated satisfactorily, and on 6 November it was released for use in evaluation.

d. Operator Proficiency

Fourteen test periods were held for the express purpose of improving operator proficiency. The results of these tests form an important part of the data used by a recently established operator integration section within Group 64 whose objective it is to suggest improvements in operator procedures. The section works closely with the AFCRC operator training organization. Reports of operator performance are collected from test observer personnel; problems that emerge are confirmed, analyzed, and diagnosed. A final statement of requirement for further training, with suggestions for implementation, is then presented.

2. Test Results

a. Montauk Radars

The long range radar and one semiautomatic height finder at Montauk were integrated into ESS. The data inputs – height, search, and Mark X – were found to be compatible with the DCA program and were correctly processed. Search and Mark X data registration was within one mile of the other long range radars. The positive reply rate and the accuracy of the height finder compare favorably with the performance of the other ESS height finders.

b. Gap Filler Radars

In November four system tests of gap filler radars were conducted in ESS. Three used live data inputs, and one used tape recorded input data. One of the live tests was conducted at midnight, a period of low traffic density, for comparison of track and data counts with normal daytime conditions. Test aircraft flew at altitudes of from 2000 to 15,000 feet. Automatic gap filler radar mapping was used on three of the four tests.

A detailed analysis of data has not been completed, but preliminary results based on visual observation and the examination of a small sample of data indicate that the DCA program appears to implement the design specifications correctly. Data coordinate conversion and transformation are done correctly. Data from the Scituate and Chestnut Hill gap fillers register within one mile of the data from the long-range radars at Bath, South Truro, and Montauk. A track of correlated data of an aircraft passing from Scituate into Chestnut Hill coverage was essentially linear, with no serious discontinuity or misalignment. Data samples from Halibut Point and Derry are not conclusive as yet. Data counts of the daytime tests are somewhat higher than expected – about 30 pieces per radar per frame. The nighttime test yielded a significantly lower figure.

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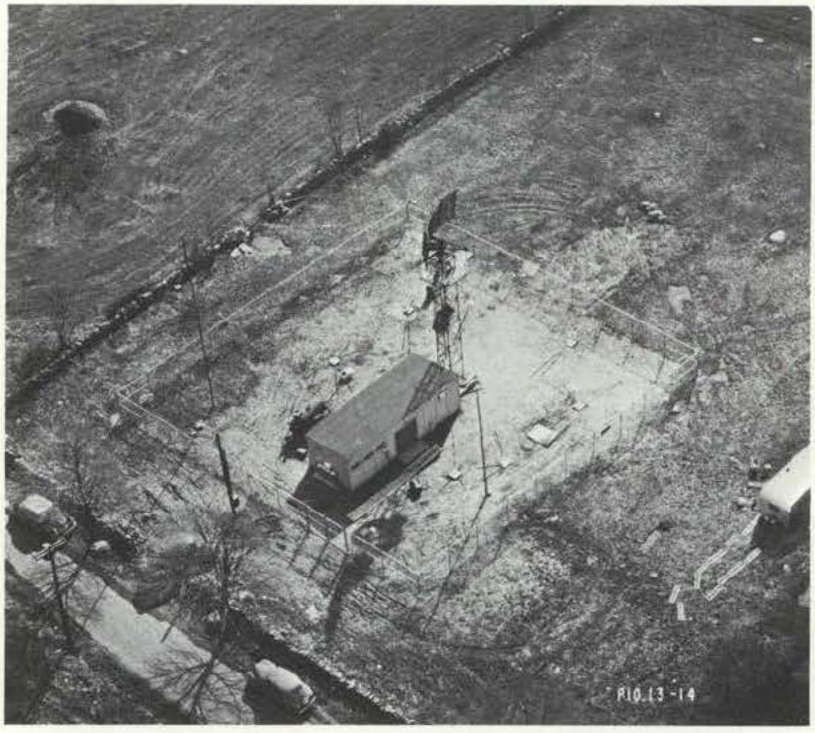

Fig. 64-4. Gap filler radar, Chestnut Hill, Connecticut.

The large amount of track data provided by gap fillers has been encountered previously in Cape Cod and ESS testing. During normal daytime operation it is not unusual for a single gap filler radar to report 15 to 20 tracks. The track data, together with noise and clutter, creates a display problem for direction center operators, especially track initiators and track monitors. While this normal load problem is under study, comparative data will be collected under conditions more typical of wartime or SCATER,* when few transient, small civilian aircraft are flying. Such conditions are approximated during nighttime or early morning.

D. MEMORY TEST COMPUTER

MTC continued reducing test data and producing simulated-data-generation tapes in support of ESS shakedown testing. Group 22 used the computer for SAGE simulation studies. Group 64 further intensified its maintenance of the computer to meet the increasingly pressing demands: the maintenance staff was augmented, the reliability of the input-output system was increased, and additional marginal checking circuits were installed. As a result, average lost time per interrupting incident was reduced to one-seventh of last quarter's figure (see below).

It is planned to transfer the job of reducing ESS shakedown data next quarter to a recently acquired IBM 704 computer, now being readied for the task.

* Security control of aircraft traffic and electromagnetic radiations.

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MTC performance, including input-output equipment, was as follows:

Total Computer Hours	2184
Per Cent Good Time	88.9
Mean Free Time (Hours)	6.52
Average Lost Time per Interrupting Incident (Hours)	.73

E. WHIRLWIND I COMPUTER

The maintenance of WW I and its associated input-output equipment is a Group 64 responsibility. A realignment of the display system was started which will include a new intensity gate and reworking of the vertical and horizontal decoders, line drivers, and deflection amplifiers. A new test program was written to assist Group 63 in its development of a remote display facility: data produced by WW I in Cambridge was transmitted via telephone line to the display tube at Lincoln Laboratory.

WW I performance, including input-output equipment, was as follows:

Total Computer Hours	1748.5
Per Cent Good Time	98.0
Mean Free Time (Hours)	19.9
Average Lost Time per Interrupting Incident (Hours)	.33

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VACUUM TUBES

GROUP 65

YOUTZ, P., *Leader*

CLOUGH, T. F.

PALERMO, J. S.

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V. VACUUM TUBES
GROUP 65

A. SUMMARY

Two years of operational experience with Stromberg-Carlson Charactron display tubes in AN/FSQ-7(XD-1) consoles indicate that the tubes have an average life expectancy of about 5000 hours which is limited by the emission from the oxide cathodes. Significant improvements in the life of oxide cathodes can be obtained only with a concerted research and development effort. Studies of bariated-nickel cathodes have indicated an improvement in life expectancy, but, production of them might encounter problems which would offset any advantages to be gained by changing the specifications of the situation-display tube cathodes at this time.

After two years of operational experience in AN/FSQ-7(XD-1) consoles, Typotron digital display tubes manifest an average life expectancy of about 6000 hours. Deterioration of the storage surface is the end-of-life factor for this tube. Machlett Laboratories, under contract to Hughes Aircraft Company, is about ready to produce prototype Typotrons to qualify as a second source of supply. Hughes Aircraft Company has developed an electrostatic convergence Typotron which is being evaluated by the IBM display tube group: it is interchangeable with the present Typotron and does not require the magnetic convergence coil and mount now used. Ten Tonotrons, half-tone electrostatic display tubes of 5-inch diameter, have been purchased to evaluate the storage surfaces for controlled persistence. Hughes Aircraft Company, under contract to IBM, has been developing character-writing, direct-view storage tube of large diameter with controlled persistence.

Group 65 has continued to develop an improved situation-display tube by replacing the phosphor in the Charactron with a sandwich panel of persistent electroluminescent and photoconductive layers. A glass embedment electroluminescent layer was developed to withstand the vacuum tube bakeout cycle.

Group 65, in cooperation with the IBM tube groups, has been following the research, development, and production, of the four receiving type tubes used in the AN/FSQ-7(XD-1) central computer and display consoles: a low-power twin triode (6414), dual-control gate pentode (6888), high-power twin triode (2399), and deflection driver (6161). In view of the fact that the tube designs have been proven and production requirements are being met, Group 65 will no longer follow these programs.

P. Youtz

B. DISPLAY

Group 65 continued to evaluate, for SAGE situation-display requirements, the production and performance of Charactrons manufactured by Stromberg-Carlson and Machlett Laboratories.

1. Charactron

a. Production at Stromberg-Carlson

Stromberg-Carlson increased their production rate over the previous quarters because of increased demands and a lower realization rate. For the three months ending November 1957

they produced a total of 256 tubes of which 70% were accepted. Three major production defects were screen quality, breakdown, and beam uniformity. The screen rejects were the results of black spots which had passed the in-process limits. Their quality control department decreased the size limit of the spots from .025 inches to .015 inches in an effort to reduce the number of rejects reaching final test. The source of breakdown rejects was traced to the presence of foreign material condensing on the electron gun. The trouble was easily removed by a short burst of high voltage energy. The cathode rejections began with a specific lot of electron guns which had a translucent white material on the A-2 barrel that turned black when the gun was heated. Although the next lot of guns did not exhibit this contamination, the cathode reject rate remained high.

b. Production at Machlett Laboratories

Machlett Laboratories is the second source of Charactrons and has been able to benefit from the production experience of Stromberg-Carlson. During the three-month period ending November 1957, they produced, under their trade name Scriptron, 79 display tubes of which 90% were accepted.

c. Life-Test Programs

Charactron life test data has been gathered at Stromberg-Carlson, the IBM-Kingston display-tube group, and Group 65. Charactrons have been accumulating operational life in the display consoles in AN/FSQ-7 (XD-1), (XD-2), and the sites. Of the 34 prototype and early production Charactrons life tested over a three year period by Group 65, all except 4 had low cathode current as their end-of-life limit.

For two years Stromberg-Carlson has been operating life-test racks on which Charactrons, ranging from early prototypes to current production units, have been tested. Forty-seven of their own Charactrons and three Machlett Laboratory prototype Scriptrons have been life tested. One Machlett tube failed at 340 hours for a grid-cathode short; the remaining two are still on life with 6999 and 7287 hours, respectively. Thirty-two of the Charactrons had an average of

Fig. 65-1. Glassblower joins neck of experimental 19" display tube to funnel.

4440 hours to failure; all but two of the failures were for low cathode current. The average life of the entire 47 tubes was 4060 hours.

The operational life history of the Stromberg-Carlson Charactrons in AN/FSQ-7(XD-1) since December 1955 is summarized below:

	A-C Hours	D-C Hours
Average hours of 74 Charactrons in operation – 1 December 1957	5393	5016
Average hours of 97 Charactrons removed (except those removed for accidental damage)* 1 December 1957	6249	5326
Combined average hours of 74 Charactrons in operation and 97 Charactrons removed* (except those removed for accidental damage) 1 December 1957	5879	5192

d. Oxide Cathode Studies

In early 1955 a program was initiated to process and test 60 tubes to study different activation schedules and cathode materials for oxide-coated cathodes (see Figs. 65-1, 2). After almost 4 years of life test, the study, which ended in November 1957, indicated that the materials and procedures which had been developed by Group 65 were optimum for the state of the art. The experiments indicated that a long and expensive research and development program would be necessary to gain a significant improvement in the oxide cathode for situation-display tubes.

Fig. 65-2. Assembly of matrix cylinder and electron gun for a 19" display tube.

*From initial installation through 1 December 1957.

e. Bariated-Nickel Cathodes

The bariated-nickel cathode studies were also concluded in November 1957. Four 19-inch display tubes which had been prepared with bariated-nickel cathodes were removed from the life-test racks after an average of 9145 hours. They were turned over to the IBM display-tube group for comparison with similarly aged Charactrons with oxide-coated cathodes. Although Group 65 is planning no further development work at this time, fabrication and processing procedures were prepared which can be used as a starting point if one of the tube vendors or IBM should decide to initiate a product improvement program. In addition to the four large display tubes, two series of experimental tubes were made during this study.

CT-100 series. The first experimental tubes containing bariated-nickel cathodes were made as diodes and triodes. These experiments were designed to determine: (1) methods of cathode mixing, pressing, and sintering; (2) cathode design; (3) grid-cathode spacing; (4) processing techniques. At the conclusion of the bariated-nickel tests, the 5 diodes remaining on life test had accumulated an average of 16,361 hours and the 12 triodes had an average of 14,596 hours.

CT-300 series. Cathodes of various mixtures were mounted in Superior Electronics 5-CP gun structures and installed in 2-inch diameter cathode-ray tubes. Seventeen of the original 93 tubes put on life test have an average of 12,515 hours. They will continue on life test and their condition will be checked monthly.

2. Typotron

Group 65 continued to evaluate the factors affecting the reliability of storage tubes for digital data display in AN/FSQ-7.

a. Production at Hughes Aircraft

The analysis of purchase acceptance data on Hughes Aircraft tubes indicated that production was concentrated near the acceptance limits. A consistent shift toward the limits during recent months could be indicative of future trouble.

The time lag between tube production and operational experience at the sites is too great to uncover potential troubles until a large number of tubes have been made. Furthermore, AN/FSQ-7 (XD-1) does not get sufficiently representative samples of current production runs to be useful as an operational life-test program. These problems have been discussed with Hughes Aircraft and the IBM display-tube group and a corrective program is being planned.

b. Production at Machlett Laboratories

Machlett Laboratories started engineering activity 24 January 1957 under contract to Hughes Aircraft to establish a second source of 5-inch, character-writing storage tubes and made the following progress this quarter: (a) assembled and processed tubes for the prototype program, (b) obtained test results for performance evaluation, (c) continued equipment procurement and installation, (d) continued production training. Results obtained to date have brought two defects to light. First, the lack of component orthogonality was traced to a slight ratio misalignment of indexing pins in an assembly jig, together with tolerances accumulated in other operations. The second problem was low secondary emission from the storage surface of the three best-effort tubes: poor write and erase times were the result. The correction of these problems is expected

in the next quarter during which Machlett plans to: (a) continue the investigation through storage-assembly processing and treatment, (b) continue the prototype tube production program, (c) start shipments of tubes to Hughes Aircraft, (d) continue to test and evaluate for correlation with the results at Hughes Aircraft.

c. Life-Test Programs

Eighteen early production Typotrons were life-tested by Group 65 from April 1955 to November 1957. They were continued on life test after they failed to meet display specifications in order to evaluate the possible life of the cathodes in each Typotron. Seventeen tubes with an average of 18,267 hours still met cathode specifications when the life test was discontinued in November 1957. Tests show that the storage surface is the end-of-life limit for this tube type.

C. RECEIVER TUBE AND RESEARCH ENGINEERING

Group 65 has been following the research and development, early prototype production, and production of tubes for AN/FSQ-7 since November 1952. All of this work was done in cooperation with the IBM tube group which had the prime responsibility for the program. Several years of operational experience with these tubes has been obtained in AN/FSQ-7(XD-1) and the production SAGE sites. Group 65 will no longer follow these programs but will be available if any problem areas develop.

1. Low-Power Twin Triode (6414)

The military specifications for the 6414 have been made final and accepted. Both General Electric and Raytheon are manufacturing this tube at satisfactory quality levels. IBM is maintaining a four-month inventory and the specification seems to be adequate to control the product for its use in SAGE.

2. Dual-Control Gate Pentode (6888)

Both Sylvania Electric Products and Bendix Aviation Corporation supply this tube. Quality has been good and a single source could maintain the four-month inventory required by IBM. However, both sources will be encouraged to manufacture the 6888 although the test specifications are not adequate to cover its use in SAGE. IBM and Sylvania have been gathering data but a realistic and satisfactory pulse plate-current specification has not yet been established.

3. High-Power Twin Triode (2399)

The Chatham Electronics division of Tung-Sol Corporation is now the sole source for the 2399. Chatham is producing tubes of acceptable quality and IBM is maintaining a three-month inventory. The 2399 is a difficult tube type to make because of its close interelectrode spacing and relatively long cathode-grid structure. Tung-Sol has the DTB-587 under development as an improved replacement for the 2399. Data is being gathered and evaluated for a specification and present indications are that this tube can be in production by June 1958.

4. Deflection Driver (6161)

The deflection driver tube (6161) in the display consoles of AN/FSQ-7(XD-1) continues to have a high failure rate. Tubes with the RCA improved cathode construction have been installed

in AN/FSQ-7 (XD-1) where they are being monitored. The tubes still have too many grid-cathode shorts for SAGE use, and RCA has suggested that a development program will be needed to eliminate this inherent defect.

D. RESEARCH

1. Controlled Persistence Tube

Since 1 August 1957 Hughes Aircraft, under contract to IBM, has been developing a large diameter, character-writing, direct view storage tube with controlled persistence. The development aims to adapt known techniques in small diameter storage tubes to large diameter tubes. Some modifications of the storage tube characteristics would be required for a device adaptable to the SAGE system. The development program has been divided into three phases which are being worked on at the same time.

The first phase deals with the mechanical problems of constructing a 21-inch tube, including the design of the flood gun, collimating lens, and target structure. Two 21-inch, spot-writing storage tubes in metal-cone envelopes have been constructed. The problems of magnetization, neck shadowing, and accelerating lenses have prompted consideration of an all-glass envelope. The panel with the target assembly will be joined to the funnel of a round, 21-inch, all-glass color-TV bulb, with a frit seal, at 440°C. The effects on the storage surface of this thermal-setting heat cycle are not known. Studies of the flood gun and its collimating system have been conducted in demountable tubes to (a) develop the collimation for best tone uniformity, (b) obtain more flood-gun current for fast erasure and brighter display, (c) minimize the coarse moiré observed during fade erasure due to collector shadowing. The most promising system has been a triple flood-gun cluster on-axis and a double lens collimator. This system will be evaluated further in the sealed off, 21-inch tube. A method has been developed to provide a highly transparent curved collector mesh.

The second phase concerns the development of a character-writing gun with the current density required for high-writing speed. Experimental cathode-ray tubes have been built to test electrostatic-convergence writing guns with beam currents of 500 microamperes at the matrix. During the next quarter guns capable of 700 microamperes matrix current will be built.

The third phase involves the development of a target to obtain increased writing speed. The capacitance of the storage surface was increased by using thicker dielectric to give a three-fold increase in writing speed, a five-fold increase in erasure speed, and a five-fold decrease in persistence. The results have been promising, but better uniformity and adherence of the thicker target surfaces is being sought.

2. Tonotron Life Tests

The type of storage surface to be used in the small diameter, controlled persistence tubes has not been tested under SAGE operating conditions. Ten electrostatic Tonotrons have been purchased for Group 65 life tests; the old Typotron life racks are being modified for this purpose.

3. Solid-State Displays

The objective of the program is to prepare and study persistent-emission, solid-state display panels inside cathode-ray tubes operating under direct beam bombardment. The panels

consist of a sandwich of electroluminescent and photoconductor layers. Five cathode-ray tubes were constructed with Group 26 panels to study the compatibility of these solid-state layers with vacuum-tube processing and electron bombardment. One tube has been put on life test. None of these tubes had been vacuum baked and for this reason the oxide-coated cathodes of the electron guns have not held up on life test. It will be necessary to develop the processing of the photosensitive layer so that it is more compatible with the cathode-ray tube bakeout cycle, or, alternatively, incorporate a getter that will continuously pump the unbaked tube.

Group 65 is producing sandwich panels for vacuum-tube evaluations. One problem is that of developing techniques for putting transparent stannic oxide coatings on the substrate and a top-transparent, metallic conductor on the photoconductor for the electrical terminals of the sandwich panel (Fig. 65-3). The problem is to find a good transparent conducting film that will withstand a vacuum bakeout.

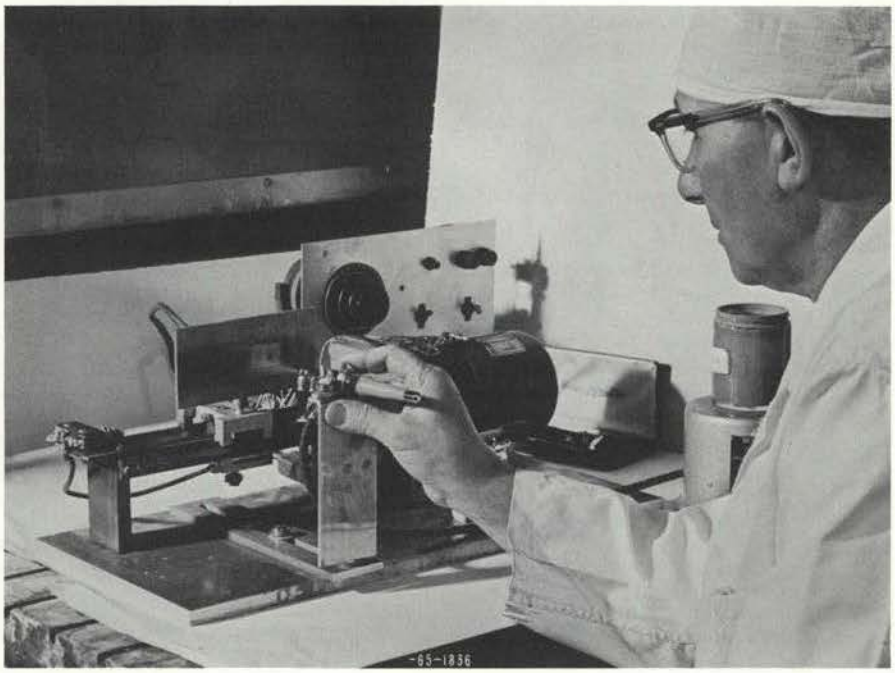

Fig. 65-3. Spraying stannic oxide test strips for evaluation in experimental electroluminescent panels.

Commercially available electroluminescent phosphors have been embedded in an organic binder between electrodes for evaluation. The better phosphors were used in electroluminescent panels for the optical memory panels of Group 26 which needed no vacuum. To find electroluminescent layers compatible with vacuum tube application, a technique was developed to embed the electroluminescent phosphors in a glass frit. A glass powder was found that will carry the phosphor unharmed through the sintering of the layer to the conducting glass substrate. Although the glass powder used is a suitable medium, it has not been established as the best for the purpose and other glass powders will be investigated. In cooperation with Group 26, Group 65 is

preparing to produce photoconductors by doping cadmium sulphide and fusing the impurities by heat treatment. These conductors will be applied to cathode-ray tube face plates, fused, and sensitized.

One of the conditions imposed on the geometry of the display panel is optical isolation between the individual display cells. Experiments were continued to settle the photoconductor through a wire mesh to give a matrix of small discrete photoconductive cells, each of which could operate in its own bistable mode. Although results were promising, a method developed by Group 26 was adopted in which a matrix of separate cells was obtained by air abrasive through a metal stencil or by selective chemical poisoning of the cadmium sulphide layer.

A life test program has been set up to evaluate different types of electroluminescent layers. The sandwich panels were put in a strobe-light life test.

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COMPUTER PROGRAM INSTALLATION

GROUP 66

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VI. COMPUTER PROGRAM INSTALLATION
GROUP 66

A. SUMMARY

Group 66 turned over the SAGE program installation responsibility to the RAND Implementation Group on 1 October. On that date, the status of the air defense computer program in SAGE sites was as follows: at the McGuire Direction Center, Package D, including duplex and switchover capability, had been turned over to Western Electric Co.; at the Stewart Direction Center, the testing of Package D was more than half completed; at the Syracuse Direction Center, testing of Package D had just begun. At IBM-Kingston, the Santa Monica test operation team left for RAND, Santa Monica. Group 66, "Special Studies," was formed to study air traffic control in its relationship to SAGE.

B. E. Morriss

B. TRANSFER OF RESPONSIBILITIES TO SDC

On 1 October Group 66 turned the responsibility for installing the air defense computer program in SAGE sites over to the RAND* Implementation Group. Certain Group 66 personnel remained under temporary assignment to the Implementation Group in order to complete their assignments. By the end of the quarter Group 66 (as a program installation group) had dissolved and its members were transferred to other groups. Group 60 took over residual administrative and service responsibilities at Kingston and McGuire.

At the time of transfer of responsibility, the status of the air defense program in the SAGE sites of the first module was as follows:

1. McGuire Direction Center

Package D of the DCA program had been checked out, demonstrated to Western Electric, and turned over to them on 13 September. A new version of Package D which included duplex and switchover capability was turned over to Western Electric Co. on 30 September. Model O, the first revision of the air defense program, was being assembly tested: the Group 66 site supervisor remained at McGuire to help RAND prepare the program for turning over to Western Electric in December.

2. Stewart Direction Center

The testing of the air surveillance portion of the D-2 package was essentially complete and the testing of the weapons direction function was in progress.

3. Syracuse Direction Center

The testing of the D-2 package had begun in September; no major portion was completely tested.

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* Became System Development Corporation on 15 October 1957.

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4. IBM, Kingston

The Santa Monica test operation team had left for RAND, Santa Monica upon completion of its training. This was one of ten teams which had been prepared under Group 66 supervision to install and test the air defense program in all SAGE sites.

C. GROUP 66 – "SPECIAL STUDIES"

In November a new group was formed to study air traffic control and its relationship to SAGE. Initial plans include an experimental data and display link between the Boston Air Route Traffic Control Center and the Whirlwind I computer in Cambridge. The new group is called Group 66 – "Special Studies"; it will be headed by D. R. Israel, now the leader of Group 61.

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SYRACUSE COMBAT CENTER

Division 6 continues to direct the installation of the combat center active (CCA) program in the AN/FSQ-8 at the Syracuse Combat Center. After 1 October, when RAND relieved Group 66 of program installation responsibilities at the McGuire, Stewart, and Syracuse Direction Centers, this remained the only Lincoln Laboratory administrative responsibility at a SAGE site.

Ninety per cent of the CCA program had been parameter checked by the end of the quarter. The air surveillance portion was about 95 per cent assembly tested. Instrumentation programs, including a simulation system and a recording system, were well under way.

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ADVANCE SAGE PROGRAM DEVELOPMENT

GROUP 67

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HAGER, L. S.
HALPERN, BARBARA M.
HILLS, MERITHEW
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LUNDBERG, E. D.
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MEAD, W. H.
MILBERT, A. J.
NEWHALL, H., JR.
ORNSTEIN, S. M.
PATTON, R. L.
PENDERGRAFT, E. D.
PORT, S. C.
RISING, H. K.
SEDGEWICK, NORMA
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VII. ADVANCE SAGE PROGRAM DEVELOPMENT
GROUP 67

A. SUMMARY

Dual tracking, a feature which improves the ability of the automatic tracking program to distinguish between maneuvering aircraft and spurious radar data, was written for the ESS DCA program. The crosstell function of Model O of the DCA program was undergoing revision preparatory to its shakedown in ESS; a closed loop between the crosstell input and output elements will enable AN/FSQ-7 (XD-1) to act as both sender and receiver. The operational specifications for Mode II (adjacent sector disabled) capability were virtually complete, and a study of their probable effectiveness in the 26th Air Division was started.

Twelve out of fourteen subprograms of the track-while-scan (TWS) portion of the SAGE non-real-time (SNORT) simulation were checked out, assembled, and recorded on magnetic tape. A study of the 1959-60 SAGE DCA program was begun to determine whether the addition of BOMARC, Nike, century-series interceptors, automatic target-battery evaluation, and Mode II capability will result in a significant increase in operating time and storage requirements, and to estimate what the track capacity of the revised system will be. The writing of improved support programs was begun which will take advantage of the larger storage of the 65,000-register core memory to be installed in AN/FSQ-7 (XD-1) in October 1958.

C. A. Zraket

B. OPERATIONAL DESIGN

1. Dual Tracking

A modification of the automatic tracking function of the ESS DCA program was initiated which will make it better able to differentiate between spurious radar returns and maneuvering aircraft. The modified logic is called dual tracking; it enables the tracking program to initiate tentative, undisplayed vectors on radar data received near a displayed track. The undisplayed vectors, of which two is the maximum number, are called dual tracks; they are carried by the program until a data scoring scheme determines whether the dual tracks are spurious or actual. If actual, they are displayed as verified aircraft tracks.

Figure 67-1 illustrates the principal features of dual tracking logic in a sequence of frames during which an aircraft turns sharply. In frame 3 the radar return (X) shows the aircraft beginning to turn. In frame 4 the return is outside of the small search area and a dual track is initiated. Meanwhile the displayed track has been extrapolated to a predicted position based upon the previous speed and heading. Beginning at the same time, the data for both displayed and dual tracks is scored. Credit is given if a radar return falls within the search areas and subtracted if it doesn't. The dual track receives radar returns in its small search area for two more frames, outscores the displayed track in frame No. 6, and in frame No. 7 is displayed as a verified aircraft track. The old track then reverts to dual-track (tentative) status for two frames, and is finally dropped.

By the end of the quarter, coding of the dual tracking function was almost finished and the ESS DCA program had been modified to incorporate it.

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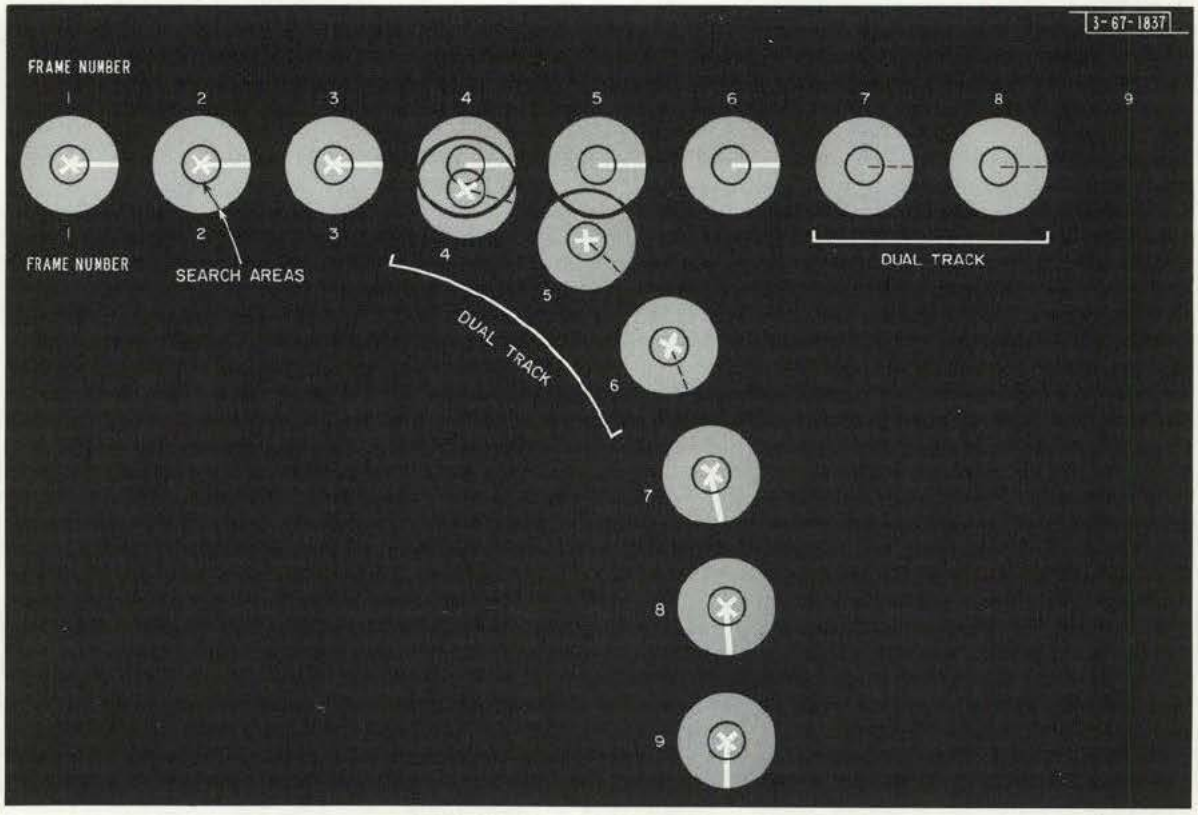

Fig. 67-1. Dual tracking logic in an aircraft turn (see text). The search areas and dotted vectors are used by the program logic but not displayed. The white vectors and radar returns (X) are displayed.

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2. Crosstell Test Facility

Modifications to the DCA program, Model O, were made which will enable Group 64 to test the crosstell function in ESS shakedown. A closed loop between the direction center crosstell input and output elements enables AN/FSQ-7 (XD-1) to act as both sender and receiver. Special program routines were also required to improvise duplicate storage and display of data.

In order to carry out its plan, Group 67 first found it necessary to revise a substantial portion of the crosstell function in Model O and to add functions not included. For example, no digital displays had been provided; and forced displays were not sent to the intended consoles in the weapons room. In addition to the program discrepancies, equipment malfunctions were encountered in the ESS direction center input-output elements; a special program, crosstell check, was begun which will assist IBM in locating the faulty components.

At the end of the quarter, the improvisation routines were complete and they were being used to diagnose the remaining discrepancies in the crosstell function of Model O.

3. Emergency Capability (Mode II)

Operational specifications for emergency capability (Mode II) were nearly complete.* In Mode II operation, two SAGE sectors adjacent to a disabled sector expand their air defense responsibility and authority over specified portions of the disabled sector. The operational specifications outline the principles of Mode II operation and describe the program, equipment, and communications changes required to implement them. The specifications were drawn up with reference to those SAGE functions which will be operational in the 1959-60 period. The effect on Mode II operation of time-division data link, which is not to be introduced until after 1959, is the subject of a separate study.

A study was undertaken to examine the air surveillance capability of sectors in Mode II operation under hypothetical situations set up in the 26th Air Division. Artificial sector boundaries and expand zones will be laid out, radio and radar coverage calculated, and weapons control capabilities evaluated.

C. PROGRAM DEVELOPMENT AND SUPPORT

1. SNORT-TWS

Group 67 is responsible for writing the tracking program for the major ESS simulation, SAGE non-real-time (SNORT). The tracking program, track-while-scan (TWS), was virtually complete at the end of the quarter:† Twelve out of fourteen subprograms had been coded, checked out, assembled, and recorded on magnetic tape. In this status the program cycled in the computer without major difficulty.

Five TWS support programs were also written and operated successfully: four of these will perform loading, simulation, and output processing functions in both assembly testing and system operation. The fifth, for use in assembly testing only, is a temporary substitute for the simulated aircraft radar data (SARD) tape now in preparation by Group 61.

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*To be published as 6M-5264-1, "Operational Specifications for Emergency Capability (Mode II) in the SAGE System," by H. Gochman.

†To be published as 6M-5693, "SAGE Track-While-Scan Simulation Program."

2. Program Cost Evaluation of the 1959-60 Revised SAGE Program

A study was initiated to predict the operating time and storage requirements of the 1959-60 revised SAGE DCA program. BOMARC and Nike missiles, the automatic target-battery evaluation (ATABE) function, century-series interceptors, and emergency (Mode II) capability were assumed as the major additions to the present DCA program. Frame time equations were derived, each containing some 1800 parameters, for both present and future versions of the program. These will be simplified and evaluated to determine 1) whether they represent a significant increase in program operating time and storage requirements and 2) what the track capacity of the system will be.

D. SUPPORT PROGRAMS FOR AN/FSQ-7(XD-1)

A new system of support programs was begun in anticipation of changes which are scheduled for AN/FSQ-7(XD-1) and the air defense program in October, 1958. Support programs consist of utility, instrumentation, and output processing programs which enable Group 67 to code, test, and document experimental DCA programs in the shortest possible time. The principal computer change that will make the present support programs obsolete is the large increase in random-access storage capacity to be introduced by the 65,000-register core memory, and accompanying changes in index logic. The new support programs will take advantage of the larger storage. In addition, improved design will make them simpler, faster, and more accurate than present support programs.

A utility program was written which produces a printout of any other program, noting for each word or instruction those combinations of digits which could cause the program to fail when operated in the modified AN/FSQ-7(XD-1). The programmer inspects the flagged items on the printout, verifies that they will cause trouble, and makes them compatible with the new memory index logic.

SYSTEM OFFICE

GROUP 68

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VIII. SYSTEM OFFICE
GROUP 68

A. SUMMARY

Seven System Office Recommendations were released by Technical Information Release (TIR) during the quarter which covered program changes to be included in Model 1 of the direction center active (DCA) program. The two most significant of these changes are (1) a "quick fix" to intercept direction calculations as an interim measure to increase the kill capability during early system operation until the double-turn modifications become available, and (2) those necessary for operation with frequency-division data link.

The redesign of the DCA program to provide the operational capability required for the 1959-1960 period continues, together with the studies of the associated equipment modifications and operator training. The report on these studies is expected to be issued in March 1958.

D. R. Brown

B. THE INITIAL SAGE SYSTEM

Proposed changes to the equipment or programs of the SAGE system are first studied on the basis of System Office Evaluation Requests (SOER) submitted by agencies (Western Electric, IBM, Lincoln, ADC, etc.) who have discovered areas in the system that should be improved or corrected. Most of the changes to the initial SAGE system will affect models of the DCA program. The changes recommended for inclusion in Model 1 and those being studied for possible inclusion in Model 2 are described in this section.

1. Changes for Model 1 of the DCA Program

Seven System Office Recommendations, covering twelve system changes, were released to the System Development Corporation during the quarter for inclusion in a description of Model 1 of the DCA program. The recommendations are briefly described as follows:

6M-4480, To Record Fighter Command Headings in ESS and SAGE,
SOER #113,* 29 August 1957, TIR 1-214

Minor program changes to:

(a) Record the item, "command heading" (FCHD), on the master operational recording tape (MORT) to make detailed analysis of interceptor direction easier and more accurate.

(b) Record the item, "time-to-go to interception" (TTGC), on the MORT for use later when double-turn intercept calculations are introduced.

6M-5255, Quick Fix to Intercept Direction Calculations,
SOER #159, 11 October 1957, TIR 1-217

Major program changes to increase the capability of the system during early SAGE operation until the double-turn modification becomes available. This "quick fix" is an interim measure whereby the program methods of calculating intercept directions are changed to comply with the attack pattern requirements of the manned interceptors that will be used during initial SAGE operation. The resulting increase in kill capability is estimated to be two-fold.

* System Office Evaluation Request file number.

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6M-5258, Frequency-Division Data Link

SOER #143, 11 October 1957, TIR 1-218

Major program changes to meet the requirements for SAGE operation with frequency-division data link as follows:

(a) Send target altitude instead of command altitude to all interceptors, except send both to F-106A's.

(b) Send command-speed-to-fly in Mach to all interceptors.

(c) Add a new test message.

(d) Send data-link messages to committed interceptors whenever possible.

(e) Store data-link status information for the 15 required squadrons.

(f) In general, control by voice the crosstold interceptors that are not a part of the 15 required squadrons.

(g) Continue to transmit FDDL messages automatically to an interceptor that has been switched from FDDL to voice control.

6M-5260, MORT and Data Association Logic,

SOER #146, 11 October 1957, TIR 1-219

Minor program changes to improve the data reduction process for SAGE system training program (SSTP) debriefings, evaluation, and shakedown as follows:

(a) Add the item, TRCI, to the track records of MORT to indicate whether the track is or is not selected for correlation record.

(b) Modify the data-association logic so that, during SSTP operation only, the association link will be cleared when the simulated track is no longer actively associated with a system track.

6M-5261, Interim SSTP – Changes to Variable Display Equipment,

SOER's #66, 149, 230, 222, 11 October 1957, TIR 1-220

Several changes to variable display equipment to meet the requirements of initial SSTP and to provide compatibility between the equipment and Model 0 of the DCA program.

6M-5262, Interim SSTP – Changes to the DCA Program,

SOER #66, 11 October 1957, TIR 1-220

Several minor program changes to meet the program requirements for initial SSTP.

6M-5263, Digital Display Changes,

SOER's #98, 102, and 112, 9 October 1957, TIR 1-216

Minor program changes as follows:

(a) Replace the item, "radar data quality" (SDEV), with the item, "masking status" (SMKS) in the LRI summary displays, since SDEV is no longer used and SMKS is desirable information (SOER #98).

(b) Correct the airbase interceptor availability display to agree with the new format specified in CONAD Regulation 55-14 (SOER #102).

(c) Display the time-to-go to offset and intercept points in minutes instead of quarter-minutes and display the scale factor as M and S (minutes and seconds) instead of C and F (coarse and fine) to eliminate a possible source of confusion between the intercept director and the pilot (SOER #112).

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2. Changes for Model 2 of the DCA Program

Recommendations were drafted based on studies of the following five SOER's. They will be published when all agencies who must concur on them have signed the recommendation:

SOER #67 AN/FSG-1 Integration

Refers to the only major changes for Model 2 being considered by the System Office. The recommendation will describe changes in the computer program, direction center equipment, and Missile Master needed to coordinate SAGE operations with Army air defense command posts (AADCP) for the integration testing scheduled to begin in October 1958 in the Washington Sector.

SOER #81 Height Finder Message Format

Minor program changes as follows: (1) rearrange the height finder reply message to make it compatible with messages that are to be provided by the height finder consoles at the P-sites; and (2) express the Task Assignment in the request as degrees relative to the height finder antenna instead of as magnetic heading.

SOER #93 Height Quantization

Minor program changes to increase the bit values of the height request and reply messages of the DCA program in order to increase the height capability of the system from 63,500 feet to 100,000 feet.

SOER #153 AA Fire Commands

Minor program changes to modify the message makeup routine so that the fire commands to AADCP's will be more prominent and therefore less subject to misinterpretation.

SOER #247 "Intercept Impossible" Indicator – MORT

Minor program changes to record on MORT the "Intercept Impossible" indicator to aid test evaluation.

3. Other Changes in the SAGE System

System Office Recommendations not associated with a specific model of the DCA program are being drafted covering the following studies:

SOER #169 Crosstell-Input System

Refers to the potential problem of oversubscription of crosstell input channels and the requirements for guaranteed storage of all missile status and crosstell information. The recommendation will describe the equipment and program modifications that should be made (1) to increase the crosstell input channel capability of all direction centers from 12 to 24 channels without doubling the amount of common equipment, and (2) to insure drum storage of all crosstell and missile status information.

SOER #213 Crosstell Clock

Refers to the indexing of the crosstell-input clock every 1/2 second instead of every 1/4 second, so that received input data will be accurately associated with the program frame time for extrapolating track positions.

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SOER #135 RAPPI: Mark X SIF Code

Changes to the RAPPI equipment that will be needed (1) to meet the display and printout requirements for the processing of the SIF code and (2) to provide for the testing, monitoring, and quality control that will be imposed by the employment of SIF in SAGE.

C. THE REVISED PROGRAM

The redesign of the DCA program and the equipment changes, the testing, and the operator training that will be necessary to make the SAGE System capable of meeting the operational requirements specified for 1959-1960 have been under intensive study for several months. A final report of the results of these studies is scheduled to be published in May 1958 and will include recommended changes to the SAGE System to provide the capability for operating with the following features:

(1) BOMARC,
(2) Nike with ATABE,
(3) improved manned interceptors,
(4) Mode II (emergency capability),
(5) time-division data link.

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ADMINISTRATION AND SERVICES

GROUP 60

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IX. ADMINISTRATION AND SERVICES
GROUP 60

A. SUMMARY

In September a consolidated facility to prepare and process computer program materials for all divisions in the Laboratory began operation under Group 60 administration. The General Engineering Section, which furnishes design, fabrication, and assembly services to the division, provided Group 62 with devices which will assist in the maintenance of ESS direction center equipment. Among these were: additions to the display element of the Kelvin & Hughes Camera-Projector, a computer log camera, and a video test probe.

J.C. Proctor
A.M. Falcione

B. JOINT CARD- AND TAPE-PROCESSING FACILITY

In September, about 30 IBM card- and tape-processing machines were combined under Group 60 administration for use by all divisions in Lincoln Laboratory and by resident SAGE contractors. The facility provides to the users of AN/FSQ-7(XD-1), MTC, and the IBM 704 the following services: the processing of program materials, the maintenance of program libraries, the furnishing of operators for AN/FSQ-7(XD-1), and the preparation of reports for the Laboratory administration.

1. Processing of Program Materials

Card punches, verifiers, sorters, and collators prepare programs for computer input (Fig. 60-1). They are also used to perform routine computations. Tape drivers, line printers,

Fig. 60-1. Card room, Building J.

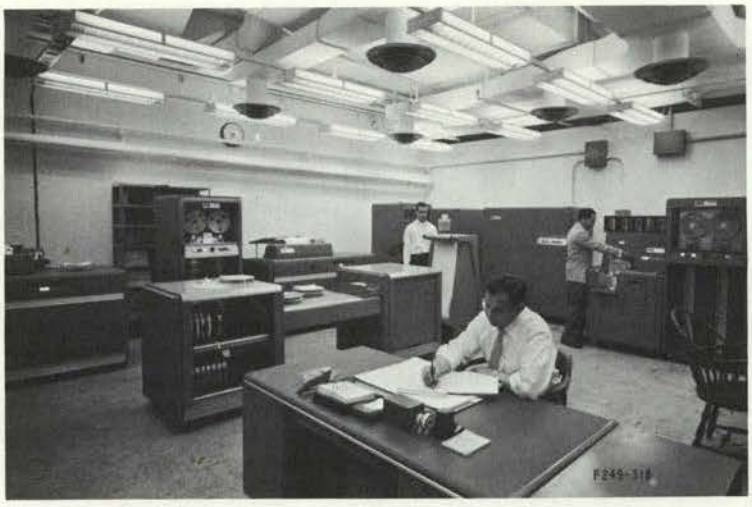

Fig. 60-2. Peripheral processing equipment, Building F.

and card machines are used in combination to produce printouts in tape, card, or list form (Fig. 60-2).

2. Program Libraries

A selected holding of the IBM SHARE library is maintained on cards, vellum printout, and tape. Locally generated programs of general usefulness are added to the basic library. All master and utility tapes, including a tape copy of the SHARE library, are kept on file. The tapes are monitored regularly for quality and edited if necessary; they are erased when they are no longer useful, graded according to their condition, and made available for re-use.

3. Operators for AN/FSQ-7 (XD-1)

Computer operators assist the users of AN/FSQ-7 (XD-1) in a number of ways: they clear the computer with a short utility program, put the user's program in the computer, diagnose program or equipment failures, and return program materials when the user is finished.

4. Preparation of Reports

The centralized data processing facility makes possible large scale assistance to the Laboratory administration. Reports and lists of personnel and equipment are produced periodically. One weekly report, for example, shows the current security clearance of all employees, visitors, and resident military personnel. A monthly report lists all laboratory equipment, its origin, past users, and present location.

C. GENERAL ENGINEERING

1. Kelvin & Hughes Camera-Projector

In order to accommodate new circuits in the display system, and to make the new and existing components more accessible for alignment, an additional frame, frame cover, and air

conditioning duct were fabricated. Power cables were shortened by two-thirds to minimize their interference with the display circuits.

2. 35 MM Log Camera

A semiautomatic camera was installed at the computer maintenance console to record the display. Enlarged prints from the film will be used by Group 62 to diagnose direction center

Fig. 60-3. Maintenance console, AN/FSQ-7 (XD-1). The dotted line indicates the field covered by the conventional log camera. This wide angle view produced by a 35 MM camera (see text) includes the marginal check controls on the panel at the far left.

equipment failures (Fig. 60-3). A selected combination of wide-angle lens, high-speed film, and fine-grain developer produced photographs of satisfactory quality.

3. Test Probe

Six trigger-operated, gun-type test probes were designed for the maintenance of the central computer. The probes can be plugged into any one of a number of jacks, permanently attached to the computer frames, which lead back to an oscilloscope at the maintenance console through impedance-matched lines. Design features include minimum input capacitance, two external capacitance controls, trigger-operated jaws shaped to grasp with equal effectiveness round or flat terminals, and a cable connector which incorporates a collet clamp to relieve tension on the conductors.

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